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Geographical Variation in Environmental Valuation of Onshore Wind Power: A Discrete Choice Experiment

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Abstract

The main purpose of this study is to investigate Norwegian households' preferences and willingness to pay (WTP) for wind power development (WPD), focusing on the different regions in Norway and exposure to wind turbines. The analysis of the environmental and social impact of wind power development will contribute to a better understanding of the balance between meeting the demand for renewable energy and preserving nonmarket environmental goods.

We have used secondary data that was carried out for the research project LandValUse (project number 319917) to investigate Norwegian households' preferences for wind power. The survey was designed as a discrete choice experience with 3 412 respondents. The multinomial logit model is employed as the chosen econometric method to analyse the data and estimate the respondent's preferences.

Our results only find some significant differences in WTP between the regions in Norway to avoid additional wind turbines. In addition, there are no significant differences for an increase in renewable energy. Western Norway significantly differs from Eastern Norway in WTP, whereas Western Norway is willing to pay more to avoid increasing turbines at all levels. We also found a significant difference between Western- and Southern Norway for an additional 1 400 turbines, with Western Norway again having higher WTP to avoid WPD. However, our results show that all regions are willing to pay for an increased grid fee to avoid additional onshore WPD. Similarly, all regions are willing to pay more to increase renewable energy.

Our research results indicate no substantial differences between people who are exposed and non-exposed to WPD within a region that is already exposed to WPD. Also, our research found no significant difference in comparing the two regions already exposed to WPD. In addition, we compared our results to previous research that investigated WTP between Oslo and Rogaland. We found similarities as Rogaland respondents were willing to pay more to avoid WPD than those from Oslo. We also discovered a difference as our study found no significant difference between the two counties regarding an increase in renewable energy. Finally, we compared our results to Dugstad et al. (2020) to see if there were any changes over time. Our data is only collected three years apart, so we found no significant difference over time.

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List of Abbreviations

CE - Choice Experiment
CV - Contingent Valuation
DCE - Discrete Choice Experiment
GHG - Greenhouse gas
MMNL - Mixed Multinominal Logit Model
MNL - Multinominal Logit Model
NVE - Norwegian Water Resources and Energy Directorate
RP - Revealed Preferences
RUM - Random Utility Model
SP - Stated Preferences
TEV - Total Economic Value
WPD - Wind power development
WTA - Willingness to accept
WTP - Willingness to pay

1. Introduction

Norwegian power production uses the most renewable energy sources and has the lowest emission levels in the European power sector (Ministry of Petroleum and Energy, 2022). Hydropower accounts for 88.2 percent of Norway's total TWh of power production, making it the country's primary source of electricity (Holstad, 2023). However, wind power has emerged as a promising renewable energy source. The country's long resourceful coastline is embraced as an element of transitioning to a low-carbon energy society (IEA, 2022). Production from wind power accounted for 10.2 percent of total electricity production in 2022 and has increased significantly over the years (Holstad, 2023).

Due to climate change, Norway has dedicated itself to sustainable growth and environmental protection by committing to the Paris Agreement and the enhanced agreement, Fit-for-55, aiming to reduce greenhouse gasses (GHG) by 50 to 55 percent by 2030 compared to 1990 (Ministry of Climate and Environment, 2021a). Wind power is a significant potential energy source for reducing greenhouse gas emissions and has received significant attention in several European nations (Statkraft, 2023). Although wind energy is considered a clean and sustainable energy source, its negative externalities are worrying due to potential effects on the environment, landscapes, and property, especially in areas with high ecological or cultural value. There has been an ongoing debate addressing ways to comprehend the environmental and social implications of WPD as Norway works to expand its renewable energy capacity and lessen its dependency on fossil fuels (IEA, 2022a). This could assist Norway in satisfying renewable energy needs and protecting environmental areas.

People's WTA and WTP, including their preferences and attitude toward wind power development, have been the subject in prior literature. In Chapter 4, we will review these studies as the foundation for our research. These studies look at the environmental cost of producing wind power and can be used as a foundation to develop climate policies and strategies for minimizing social and environmental impact while maximizing the benefit of using wind power.

A study by Dugstad et al. 2020, found that Norwegian households have a positive WTP for avoiding WPD. The research sample of Oslo and Rogaland counties to examine how the households' WTP varies. The two counties differ regarding exposure and the degree of impact of onshore wind turbines, where they have been more localized and exposed in Rogaland than in Oslo. Due to the need for studies associated with people's preferences toward wind power, we aim to examine this in more detail and extend the research with a focus on the different geographical regions in Norway.

1.2 Problem Statement and Research Questions

The main objective of this thesis is to investigate the economic damages that locals and the public sustain from the construction of wind power plants in the environment. The analysis of the environmental and social impact of WPD will contribute to a better understanding of the balance between meeting the demand for renewable energy and preserving valuable natural areas. The survey format is similar to Lindhjem et al. (2019) but with a larger sample size covering Norway’s population. The problem statement revolves around whether people still have a positive WTP to avoid onshore wind power development and if it varies between the regions.

The following problem statement is:

How does the willingness to pay of households in Norway vary with the geographical areas for onshore wind power development?

The research questions in the following section should, together with the literature and results, answer the problem statement. Table 1 lists all the research questions with the following hypotheses with supporting literature.

We used secondary data carried out by Kantar in 2022 for the research project LandValUse (project number 319917) to investigate more about Norwegian households' preferences for wind power. Participants were provided with a survey designed as a discrete choice experiment (DCE), where they had to choose between three alternatives regarding their preferences for WPD in several scenarios. Using the multinomial logit model (MNL) to measure and observe both use and non-use values. The methodology ensures the foundation of measuring and observing both use and non-use values (Segerson, 2017). Since it is extensive to measure the change in the utility level of a respondent, the stated choice can be interpreted as the probability that the representative chooses a particular alternative from those given so that the multinomial logit model (MNL) can analyse the outcome (Train, 2009).

We look at the variation in WTP between geographical areas in Norway, which considers the perspective of how individuals are willing to pay to avoid or minimize the WPD while at the same time being indifferent in well-being to the change in income. In other words, WTP deals with how much the individual is willing to accept to give up their income without affecting their welfare.

With this in mind, we can estimate results that answer the research questions and test the hypotheses.

Table 1.1: Research Questions and Hypothesis

RQ1	**How does the WTP for wind power development of Norwegian households vary from the different regions in Norway?**
H1	People have a positive WTP to increase the use of renewable energy (Dugstad et al., 2020; Zerrahn, 2017).
H2	People have a negative WTP for the increased development of additional wind turbines (Dugstad et al., 2020, and Garcia et al., 2016; Dugstad et al., 2023; Meyerhoff et al., 2010; Garcia et al., 2016; Brennan and Van Rensburg, 2016; Zerrahn, 2017).
RQ2	**How does people exposure to wind power affect people's WTP for additional wind power development?**
H3	People from Central - and Western Norway who are exposed to WPD differ from non-exposed individuals in their WTP for more WPD. (Lindhjem et al., 2019; Dugstad et al., 2020).
RQ3	**Are there any similarities in our findings compared to the research done by Dugstad et al. (2020)?**

H4	People from Rogaland have a higher WTP to avoid wind power development than people from Oslo (Dugstad et al., 2020).
H5	People are more negative to wind power development now compared to previous years (Dugstad et al., 2020).

The thesis consists of 8 chapters. The first part explores the background and relevant literature; Chapter 4 introduces the theory associated with environmental and welfare economics, followed by applying the econometric method in Chapter 5. Further, the results are presented in Chapter 6 and discussion in Chapter 7. Lastly, a summary and conclusion are drawn based on the previous chapters.

2. Background

The government reopens for more onshore wind energy after three years of having the development on hold due to the population's resistance, social challenges, and environmental disturbance. In this section, we will reflect on the role of wind energy in the energy sector and the potential of wind energy as an energy source.

2.1 Wind Energy in Norway

Wind power, classified as a renewable energy source, transforms the kinetic energy in the wind into electricity with the help of wind turbines. The rotation function on the blades caused by the wind produces power for the consumers (IRENA, 2022). More specifically, wind power is an intermitting renewable resource, meaning that electricity production varies depending on the frequency of the wind power (Energy Education, 2023).

Norwegian electricity production has shown to stand out among European countries as the highest user of renewables and has the lowest emissions in the power sector. There were 64 wind power plants (Norwegian Ministry of Petroleum and Energy, 2022) with 1 350 turbines (LandValUse (project number 319917), 2022) in Norway at the beginning of 2022. The total capacity of the onshore wind power plants is 4 650 MW and an annual production of 15.4 TWh (Norwegian Ministry of Petroleum and Energy, 2022). Norway uses approximately 150 TWh of energy a year. In 2020 there were 18 power plants distributed with 5.3 TWh produced, compared to 14.8 TWh produced in 2022. The amount of wind power production has substantially increased over the last few years. Wind power production accounted for 10.2 percent of total electricity production in 2022, compared to 7.5 percent in 2021. However, hydropower still dominates Norway's electricity generation with 88,2 percent of the total power production of TWh. As a reflection of the numbers, wind power production has increased rapidly from 2019 to 2022 (Holstad, 2023).

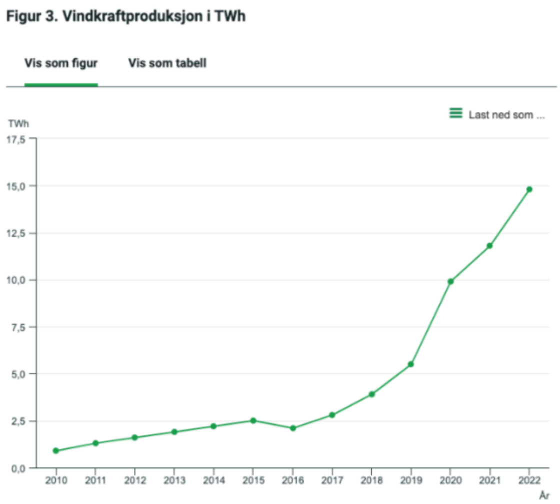

Figure 2.1: Wind power production in 2022 (Holstad, 2023)

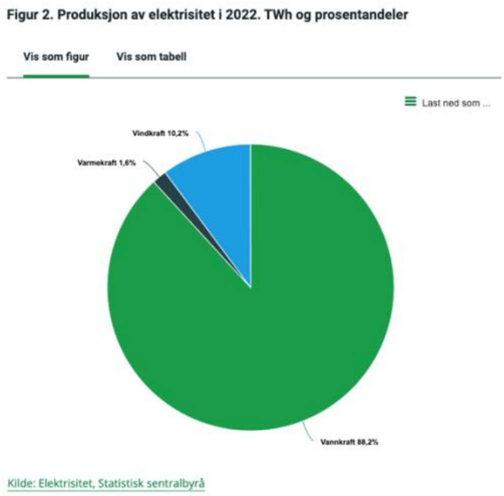

Figure 2.2: Production of electricity in 2022 (Holstad, 2023)

For offshore wind power production, the ocean offers many challenges. The offshore turbines get exposed to the harsh forces of nature, such as significant waves, storms, and saltwater, meaning they must withstand much more than onshore wind turbines. A frequent common denominator is the challenges of the distance to connecting the wind power to the electricity grid, both capacity and expansion. The electricity grid must be able to transport the power to the consumers, and building additional power grids is costly (IEA, 2019a; IEA, 2021).

Usually, onshore wind power plants are located along the coastal line, where the wind has its highest activity. Onshore wind power has the lowest average production cost in Norway with the current technology and has decreased significantly in recent years (Ministry of Petroleum and Energy, 2023a; IEA, 2019a; IEA, 2019b). Bilateral power purchase agreements have become increasingly common and are contributing to reducing the price risk for the developer (Ministry of Petroleum and Energy, 2023a). Since the production cost is significantly lower, it could benefit investment without subsidies (Vindportalen, 2023; Ministry of Petroleum and

Energy, 2023a). However, it is the stakeholder's responsibility to evaluate the investment by weighing the risk ratio of the earnings in the market (Ministry of Petroleum and Energy, 2023a).

The Energy Commission came through with a press release about an increase in energy needs in the future. The report highlights that the development of power expansion needs to happen fast. When comparing the wind energy sector to other cost-competitive electricity generation methods, historically, wind power has not proven to be the most profitable investment without subsidies (Vindportalen, 2023; IEA, 2019b). Considering the dramatic climate and environmental change, the green transition has gained more focus in the media. As a result, the development of new technology has an increasingly appealing and cost-beneficial potential advantage, making an investment in wind power more attractive (IEA, 2019a; IEA, 2019b).

Norwegian water resources and energy directorate (NVE) statistics show where wind power plants and further development of onshore wind turbines will be localized (figure 2.3). The dark green dots explain where the exciting wind power plants are localized in Norway, while the light green dots are the power plants under development. The blue triangle on the figure explains that licenses for constructing wind power plants are given, and the light blue triangle illustrates those under review. The red triangles are licenses declined.

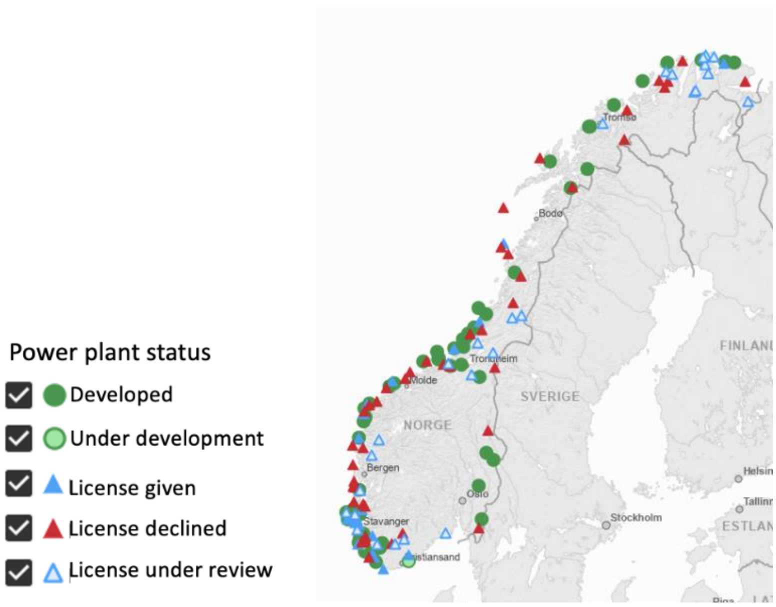

*Figure 2.3: Status of license processing of wind power plants (*NVE, 2023a)

Replacing fossil energy sources with renewable energy will be the primary focus moving forward (Equinor, 2023). The Norwegian electricity supply does approximately not emit GHG, creating a competitive advantage over other countries where the energy source is still coal and gas power (Ministry of Petroleum and Energy, 2021). It is essential to secure energy for the future need for power while maintaining the export and trade in the global economy that is growing to be green (IEA, 2022b). Wind power has great potential and the lowest development cost compared to other renewable energy, which can be essential in the green transition (Ministry of Petroleum and Energy, 2023a; IEA, 2022b).

2.2 Norwegian climate policy and regulations

Due to the political framework and regulations, Norway currently has a surplus of power. It is crucial to consider how much power will be needed in the coming generations concerning climate change, efficiency, and reliability (Ministry of Petroleum and Energy, 2023b). It is likely to be a substantial growth in power demand in the years ahead, in line with more electrification of society and the emergence of new industries with increasing power needs (Urke et al., 2023).

Norway has committed to decreasing emissions due to the climate and environmental crisis (Ministry of Climate and Environment, 2021a). Environment changes severely affect humankind, animals, species, biodiversity, ecosystems, and services, especially for species threatened with extinction. Global warming is expected to continue beyond this century, increasing the risk of even rougher extreme weather, precipitation, floods, and ocean acidification (Dessler, 2022; Perman et al., 2011)

According to the Paris Agreement, countries submit new or updated emission targets every five years. Even though there is a global agreement, the commitment is not obligated but self-enforced, resulting in unequal participation among countries. Norway is involved in the enhanced agreement called Fit-for-55, aiming to reduce GHG by 50 to 55 percent by 2030 compared to 1990 GHG levels (Ministry of Climate and Environment, 2021a; IEA, 2022). In cooperation with the climate agreement with the EU, Norway has targeted to reduce emissions by at least 40 percent by 2040 (Ministry of Climate and Environment, 2021a and 2021b). Climate policy aims to provide a framework that enables the transition to a low-emission society to reduce emissions by 90 to 95 percent by 2050 while keeping the standard of supply and energy needs at an acceptable level to the suitable price (Ministry of Climate and Environment, 2021b).

Further, Norway has committed to reducing emissions in collaboration with the EU to stay within the global target of 2 degrees that the UN Climate Panel (IPCC) presented in 2015 (WWF, 2023) and a special report on 1.5 degrees of global warming in 2018 (Ministry of Climate and Environment, 2021a). The report concludes that the risk to humans and nature is significantly higher at 2 degrees compared to 1.5 degrees. It indicates the need for rapid reductions in emissions of greenhouse gases. Significant emission reductions before 2030 entail a greater chance of limiting global warming to 1.5 degrees. The Norwegian government has confirmed having a climate policy that strengthens and facilitates reaching the climate targets by 2030 and 2050 (Ministry of Petroleum and Energy, 2023b).

The Energy Commission was established on February 11th, 2022. The primary task of the energy commission is to assess the fundamental dilemmas in Norwegian energy policy. They review different choices that can affect the long and short-term development of the Norwegian power supply (Ministry of Petroleum and Energy, 2023b). The government operates simultaneously with The Energy Commission, which recently announced the introduction of a management mechanism to help ensure supply security for power. By that, the government is providing better local anchoring in matters relating to onshore wind power. The government has proposed a framework for constructing wind power plants to secure further value creation and incentives for developing onshore power plants. In addition, they are implementing a ground rent tax for onshore wind power with the purpose of giving back to the local communities and municipalities (Ministry of Petroleum and Energy, 2023b).

In Norway, obtaining a license from the government/authorities is required to construct wind power plants. NVE handles license applications for wind farm projects. The processing time can vary from a few months to several years, depending on the complexity and broadness of the case circumstances (Jacobsen et al., 2019). The processing of the concession itself takes place by assessing the social benefits of the project against encroachment on nature and other adverse effects of any development.

2.3 Social and environmental challenges

Developing onshore wind power plants often encounter social resistance due to the intervention in the different communities (Lindhjem et al., 2022). Some studies have found negative perceptions toward onshore wind power plants in various countries, including Norway. The climate change problem is complex, and over the last few years, there has been an increased focus on social and environmental challenges.

A considerable population supports the green transition and the work toward sustainability (Lindhejm et al., 2022). Wind power can bring economic and environmental benefits, but it also comes with its cost, which involves making challenging trade-offs. Foreign corporations with complex ownership structures and tax avoidance schemes that involve moving profits to tax havens own a significant portion of the Norwegian wind power industry (Skonhoft, 2021). The interpretation of the situation is a classic example of privatising income while the social cost of carbon is socialised. Onshore wind power often meets local resistance, which causes social challenges and reduces the number of wind turbine projects (IEA, 2022b).

Recent studies show that 53 percent of the population is hostile to onshore wind power, 30 percent are positive, and 18 percent are neutral. Only 6 percent of the population is optimistic about onshore wind turbines, while 26 percent are strongly negative about further development (Lindhjem et al., 2022, p. 6). 12 percent think it is worth destroying more of nature in exchange for value creation and jobs. Only three percent of the population believe having a wind power plant 1 kilometre from their home is acceptable. The study demonstrates people's increased hostility toward onshore wind power plants since 2019. (Lindhjem et al., 2022).

The expansion of the WPD created remarkable reactions among people, especially those associated with the reindeer industry, tourism, hunting, and outdoor recreation (NVE, 2022). The government needed to consider the backlash and stop the processing of licenses for onshore WPD in 2019. In 2022, the government decided to open new onshore wind power projects with consent from the municipality (Hjellen et al., 2022; Øvrebø, 2022). The government sees the potential for wind production onshore and offshore and its role in the future energy supply. In addition, Russia's invasion of Ukraine reinforces the uncertainty about power prices in Norway and the rest of Europe, contributing to reconsidering the potential of wind power (Øvrebø, 2022).

3. Literature review

This chapter gathers information from various studies that highlighting wind turbines' positive and negative externalities, preferences towards wind energy, renewable energy, and WTP and WTA wind energy. Previous research provides an excellent review of how wind power positions today.

3.1 Externalities of onshore wind power plants

One agent's decision affects another agent's utility. This impact may be harmful or beneficial, and we can divide it into negative and positive externalities, respectively (Perman et al., 2011). A negative externality reduces an individual's utility, while a positive one will increase the utility (Zerrahn, 2017). The adverse effects of wind power can be seen as negative externalities. These are not reflected in the market prices as markets do not cover them, and no compensation is given (Meyerhoff et al., 2010).

Some of the negative externalities of wind turbines are the impact on the environmental ecosystems and wildlife. Research shows that there is increased mortality of birds and bats from collisions with wind turbines. It also affects wildlife through severe land use and construction activities (Zerrahn, 2017). Beyond wildlife, humans also experience negative externalities regarding wind turbines. People living close to wind farms are negatively impacted by the noise coming from the turbine's rotating blades, which can trigger psychological distress and annoyance. In addition, Zerrahn (2017) shows that negative externalities from visual disturbance and low visual impacts are a driver to project success for wind farms. Even though the visibility of wind farms only affects the local population, it is perceived as the main factor in negative attitudes toward wind power development (Wolsink, 2002; Zerran, 2017).

Wind power is attributed to substantially lower environmental externalities from emissions. Among fossil fuels, coal has the most adverse consequences for human health over its life cycle. Human health impacts are mostly lower, GHG emission, and accident risks, compared to nuclear power, are also substantially lower with wind power (Zerrahn, 2017; Mattmann et al., 2016).

Further research is required on macroeconomic effects like green jobs and growth. A study by Simas and Pacca (2013) done in Brazil found positive results in employment rates and found that wind power will generate over 80 000 jobs in a year. Similarly, Ortega-Izquierdo & Río (2020) found that employment growth is concentrated in Europe among three countries: Germany, Denmark, and Spain, which account for almost ¾ of all the employment that is created in onshore wind development. Some studies indicate growth in employment in GDP from wind power development, while others show modest permanent job effects and marginal financial benefits. In addition to this, wind power has a positive effect on national energy security. However, the variability of supply and dependence on resources must be considered, as supply may not be adequate when demand is high, and few suppliers of special metals are used in wind turbines (Zerrahn, 2017).

3.2 Preferences for localizing development of wind power plants

A new household survey shows tendencies toward a favourable preference for WPD (Lindhjem et al., 2022). After the opening of license processing for wind power, there was both offense and satisfaction for new wind power plans among the population (Nyhus & Hatlestad, 2022).

According to literature, people who live close to wind power plants or often nearby have a different acceptance of them than others that are not exposed in the same way (García et al., 2016; Lindhjem et al., 2019; Dugstad et al., 2020). Malnorova et al. (2010) found that the level of acceptance is better if positioning the wind turbines in an unattractive area. Landscapes far away from people's sight and limitations of additional wind turbines in the area are more accepted than high-value landscapes. Another finding from the literature is that offshore wind preferences are more attractive since the citizens see electricity production onshore and offshore as two different goods (Linnerud et al., 2022). The study encountered that the citizens interpret onshore wind power as a public good on the same level as other sectors as the road system and public transport, unlike comparing offshore wind power to private goods such as oil, salmon, and gas industries (Linnerud et al., 2022).

Furthermore, studies have found that an increase in the density of wind turbines reduces the population's positive attitudes toward WPD (Brennan & van Rensburg, 2020). Brennan & van Rensburg (2020) also touches upon "place attachment" and that people who have a relationship with the place are more oppositional than others towards WPD. Dugstad et al. (2023) also support the findings that there is a correlation to place attachment for accepting wind power plants, increased resistance towards wind energy, and its negative externalities.

Some studies indicate that consumers are more likely to accept higher renewable electricity fees if the trade-offs ensure that areas used for recreational purposes are preserved, national ownership, and involve residents in the planning and implementation process (Ek & Persson, 2014; Brennan & van Rensburg, 2020; Dugstad et al., 2020; Meyerhoff et al., 2010). Ek and Persson (2014) found that the respondents are willing to pay a higher electricity tax to avoid wind farms in mountain areas and private ownership in Sweden. Linnerud et al. (2022) findings suggest that preferences reflect economic rationality. Ensuring national and local control over ownership that helps benefit the Norwegian society, such as employment, business development, and tax revenues, is preferred. Another element may be the sense of fairness that consumption and ownership should reflect the cost of nature and the environment for local communities in the sense of control to ensure energy supply security goals and the natural environment's protection.

In research done by Wolsink (2007), it was found that attitudes toward wind power follow a U-shaped pattern. It starts with a positive attitude when people are not confronted by wind power development, to more critical when a project is announced. The attitude to wind power returns to a higher positive stance sometime after the construction. Similar findings are presented in the research by Meyerhoff (2013), where respondents who have wind turbines in their surroundings were more likely to support WPD than those without wind turbines in their surroundings, who were more likely to choose an alternative that limited WPD.

On the other hand, Zerrahn (2017) points to inconclusiveness in positive attitudes from familiarity with WPD. Several studies found that seeing turbines from "your" home or in areas frequently used results in negative perceptions toward WPD compared to those who do not (Ladenburg et al., 2013; Ladenburg, 2010). Other research also found that exposure to WPD leads to lower acceptance for additional or future WPD (Dugstad et al., 2020). People who encounter wind farms more frequently have lower acceptance (García et al., 2016; Brennan & van Rensburg, 2020).

3.3 Attitudes toward an increase in renewable energy

A recent report from Statkraft (2022) found that European consumers are positive and want an increase in renewable energy, as they have climate and affordability concerns. Of over 18 000 respondents, 69 percent believe there should be a prioritisation of renewable power development, and it was an 80 percent acceptance rate for onshore wind power development. Zerrahn (2017) also reports that people generally have a positive WTP for renewable energy and wind power.

The recent research done by Dugstad et al. (2020) shows that people in Norway generally have a higher level of WTP for increasing renewable energy production. The respondents are willing to pay an average of NOK 273 more per month to increase Norwegian renewable energy production by 30 TWh annually (Dugstad et al., 2020). Despite this, Norway's citizens have yet to fully accept more onshore wind power development. The respondents demand a reduction of NOK 415 a month for installing 3 000 wind turbines. It implies that the respondents prefer other renewable energy sources to increase production, e.g., to upgrade Norwegian hydropower and offshore wind power, as alternatives with less environmental impact but also more expensive (Dugstad et al., 2020).

Much of the literature and the studies show that the Norwegian people are optimistic about wind power as a renewable energy source and its role in the future in meeting the growing demand for electricity in Norway. However, they also identify the importance of considering nature, the environment, the climate, and other socio-factors. Although both areas are optimistic about renewable energy production and wind power, there are still negative preferences for developing onshore wind turbines, especially in their region (Lindhjem et al., 2019)

4. Theoretical framework

Non-market valuation methods require a linkage between changes in the quantity or quality of the resource and changes in the stated or observed behaviour of people. Non-markets are more challenging to measure than market values, but using valuation methods to measure the monetary value could contribute to objectifying the economic cost of non-market goods (Mariel et al., 2021). This chapter will focus on the theoretical foundation of non-market validation, environmental demand theory, and theoretical framework of measuring non-use values by looking at WTP and WTA.

4.1 Welfare Economics

Welfare economics is an economic framework that studies the optimality and effective allocation of resources and how they impact social welfare. Figure 4.1 illustrate the relationship between a private good (x) and a public good (q). The production possibility frontier (PPF) shows the yielded combination of the two goods in the economy. The social welfare function (SWF) describes the individual's economic preferences (Perman et al., 2011).

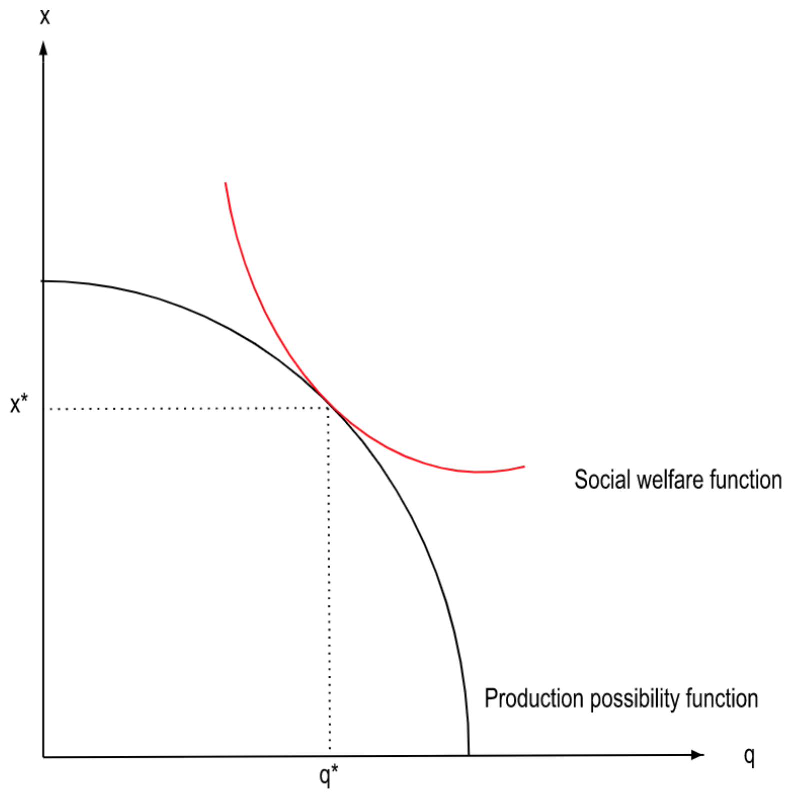

Figure 4.1: Welfare maximization - Pareto optimality

The ideal condition for welfare is when the analysis leads to Pareto efficiency, which is when SWF intersects with PPF. The implicit optimal output of private and public goods is x*and q*, and the economy is maximized. The two goods could be allocated underneath the PPF, which makes room for Pareto improvement. A Pareto improvement is known for allocating resources more efficiently than the current allocation of recourses, meaning that the changes should at least gain one individual without any losses (Perman et al., 2011). The primary purpose of welfare economics (concerning environmental validation) is to measure an individual's utility level due to a change in the supply of goods and services in the market (Perman et al., 2011). The utility function reflects how individuals can obtain utility by consuming goods concerning the budget constraint. Whenever there is an economic change, the indifference curve moves to another indifference curve with the change in preferences (Perman et al., 2011).

Pareto criterium is a fundamental theory to understand the societal allocation of resources more efficiently than the status quo (Perman et al., 2011). Policymakers must weigh the costs and benefits of implementing a policy to evaluate whether there is any room for Pareto improvement. Using valuation methods to measure the changes in preferences is ideal for analysing the costs and benefits, providing information that can help implement policies that benefit welfare.

4.2 Measure of welfare change

Using the consumer demand theory, we can explore the impact of wind energy on welfare. The general utility function can represent the consumer's preferences by:

$$U = U(X, Q)$$

Equation 4.1: The general utility function of wind power

X is the vector of the quantities of market goods ($X = [x_1, x_2, \ldots, x_n]$), and Q is a vector of the nonmarket environmental goods fixed for the individuals. Income and price in the economy enter the process through scarcity and are essential mechanisms that affect an individual's preferences. $P = [p_1, p_2, \ldots, p_n]$ is a vector of n market prices, and Y denotes household income to the respondent (Vincent & Maler, 2003).

We are looking for a way to quantify an environmental change's impact on a person's welfare. WPD affects the quality of nonmarket environmental goods (Q), which can alter the individual's income Y. The result of the change in income can be used as a measurement for the change in welfare (Flores, 2017, p. 29-33). The standard utility function of an individual is a function of a set of private goods and chosen quantities to reach the maximum utility subject to the budget constraint (income), defined as:

$$\max_{x} \; U(X, Q) \quad s.t. \quad p * x < Y$$

Equation 4.2: The Marshallian demand theory – maximization problem (Flores, 2017, p. 29-33)

The solution to this problem leads to the Marshallian demand function $x_i = x_i\ (P, Q, Y)$ where $i= 1, \ldots, n$. The Marshallian demand function tells us how much an individual is willing to consume at a given price; if the price increases, the demand will fall. By substitution of the Marshallian demand into the direct utility function derives the indirect utility function as a function of price, nonmarket environmental good, and income (Vincent & Maler, 2003, p.525).

$$U = V\ (P, Q, Y)$$

Equation 4.3: The indirect utility function of wind power

The concepts of compensating (CV) and equivalent variation (EV) are used to measure the welfare effects by looking at the nonmarginal changes. The measurement expresses how much money must be given to a person for the individual to be in the same well-being as before the change in the environmental quality. Using the indirect utility function to illustrate CV can be defined as:

$$V\ (P^0, Q^0, Y^0) = V\ (P^1, Q^1, Y^1 + CV)$$

Equation 4.4: Illustration of compensating variation

Subscriptions 0 and 1 denote the level of the parameter and have the same signs as the welfare change. Wind power production deteriorates the quality of nonmarket environmental goods, then changing $Q^0 > Q^1$, while $Y^0 = Y^1$ and $P^1 = P^0$. $CV < 0$, the negative amount of money must be given to the individual for compensating the welfare loss to leave the individual as well off as he was before the change (Vincent & Maler, 2003, p 527). Equation 4.4 explains the willingness to accept (WTA) with change in Q with compensation to obtain the utility status quo (Mariel et al., 2021).

The equivalent variation is another option for measuring the individual utility level, looking at the amount of money that must be deducted from income to leave the person at the same level of well–being as before the change. This perspective looks at how much an individual is willing to give up avoiding the change of quality of Q and still obtain the same utility as before the change.

$$V(P^0, Q^0, Y^0 - EV) = V(P^1, Q^1, Y^1)$$

Equation 4.5: Illustration of equivalent variation

It is frequently helpful to state these measures directly regarding expenditure function to build the mechanism for measuring the CV and EV associated with the changes in Q (Vincent & Maler, 2003, p. 527). The duality of the individual's utility maximization problem is defined by the Hicksian demand theory, which centralizes the variation in the expenditures of a respondent (Mariel et al., 2021).

$$\min_X p * x \qquad s.t.\ \ U(X, Q) > U^0$$

Equation 4.6: Hicksian demand theory – minimization problem

The expenditure function describes the minimal amount required to obtain a certain utility level, given market price and nonmarket environmental good (Champ et al., 2007, p. 32). In other words, Hicksian demand theory says that an individual WTP is the lowest price the individual is willing to give up for a good when income changes due to the change in Q. By solving the cost-minimizing problem, the requirements for X can be substituted into the objective function which derives the Hicksian Expenditure function (Vincent & Maler, 2003, p. 527).

$$e = e(P, Q, U^0)$$

Equation 4.7: Hicksian Expenditure function

The compensating and equivalent variation of a change in Q can be expressed as following:

$$CV = e\ (P^0, Q^0, U^0) - e\ (P^1, Q^1, U^0)$$

And

$$EV = e\ (P^0, Q^0, U^1) - e\ (P^1, Q^1, U^1) \qquad \text{where } U^1 = U^0 = V\ (P^0, Q^1, Y^0)$$

Equation 4.8: Compensating and equivalent evaluation using the Hicksian expenditure function.

The duality between Marshallian and Hicksian demand theories can be utilized to find the same level of WTP/WTA for a change in the environment. We can do this by using the Hicksian demand theory to look at the effect on demand function after a change in the quality of the nonmarket environmental good (Q) and how it affects income, and then use the Marshallian demand theory to find the price which will cause the individual to be indifferent after the change in the nonmarket environmental good (Q) as they would have consumed with a higher income (Vincent & Maler, 2003).

The Hicksian demand function is considered as a better approach for measuring consumer welfare because it focuses on the level of well-being the consumer derives from their consumption choices (Flores, 2017, p. 32). The approach provides information and measurement of understanding how changes in price and income affect consumer behaviour and welfare based on revealed preferences that are stated under different scenarios and assumptions.

Table 4.1: The relationship between the Hicksian welfare measures and WTP/WTA. (Source Mariel et al. 2021. p.16)

Welfare measures	**Compensating measurement**	**Equivalent measurement**
Definition	Amount of income paid or received that leaves the individual at the initial level of welfare.	Amount of income paid or received that leaves the individual at the final level of welfare
Welfare gain	WTP	WTA

Welfare loss	WTA	WTP

4.5 Willingness to pay (WTP) and Willingness to accept (WTA)

WTP measures the maximum amount of money an individual is willing to trade to avoid WPD due to the negative impact on the environment. Using WTP contribute a value validation that an individual position a good or a service in terms of the amount of money they are willing to give up. While WTA measures the minimum amount of money an individual is willing to accept to give up a good or a service.

The main difference between WTP and WTA is that WTP is bound by an individual's income level, while WTA is not. The value foundation of giving and receiving can be influenced by many factors, such as income effects, transaction costs, and a broad spectrum of preferences (Mariel et al., 2021, p.16). There is advocated that the best practice for environmental valuation favours WTP, while WTA has been found as the best approach in low-income countries (Mariel et al., 2021, p.16). In this thesis, we have chosen to focus on comparing WTP and how it varies among the different geographic areas in Norway.

4.6 Environmental Validation - The total economic value

The total value of the environment and the natural resources are not reflected in the market's price, meaning that the total social cost is not validated. These goods are called non-market goods. They can be referred to as environmental goods and services and include several ecosystems, such as clean air and healthy ecosystems (Perman et al., 2011). The entire market depends on natural systems' existence and their proper functioning for the benefit of human well-being.

The present value (PV) calculates all the benefits of environmental services and goods. B_t explains the mathematical denotation of PV as the overall benefit received by preserving the areas at risk of exposure to wind power production over time *t*. The discount rate, *r*, represents the "value" of benefits, and *t* denotes the period when the benefit is received. Calculating the present value of total benefits from environmental goods and services depends on the discount rate. The sum of all discounted benefits determines the present value of all benefits received from environmental goods and services (Lewis et al., 2020, p.57 and p.58).

$$PV = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t}$$

*Equation 4.9: Present Value of a Non – Market good (*Lewis & Tietenberg, 2020,*)*

An economist is interested in correcting the price to justify the cost if there is a discrepancy in the market. Economic valuation techniques can provide information to justify the social cost so that the price reflects the total economic value.

Since people derive real economic value from natural resources and the environment, the total economic valuation (TEV) must include quantifying traditional "*use*" values and "*non-use*" values of environmental services and goods (Perman et al., 2011). These categories are divided into (1) direct use values, (2) indirect use values, (3) option values, and (4) non-use values (Lewis & Tietenberg, 2020, p.84; Perman et al., 2011). TEV is defined as:

TEV = direct use values + indirect use values + option values + non-use values

Equation 4.10: Total Economic Value

The direct use values reflect the use of the environmental resource in the sense of direct experience from the ecosystem; for example, wind energy provides electrical power for different industries and the experiences of hiking, hunting, and other activities the ecosystem provides. The indirect use values only partially know what the preserved resource is giving in the future (Lewis & Tietenberg, 2020, p.84). One example is how wind power contributes to emission reduction over time and the impact on future generations. Option value captures the importance of protecting the ecosystem's services and biodiversity. It focuses on people's value of their ability to use the environment in the future, even with limited information reflected in option value (Lewis & Tietenberg, 2020, p.85).

The non-use value comes from the benefit of not physically interacting with the good (Lewis & Tietenberg, 2020). The non-use values are divided into three sections: existence, bequest and altruistic (Perman et al., 2011). Some people value the existence of wind turbines since wind power represents clean and renewable energy. Bequest value represents that people set a value on WPP for the following generations' benefit as it helps preserve nature and reduce dependence on limited fossil fuels. Some set an altruistic value on WPP for its potential future power use, even if they do not directly benefit from it (Perman et al., 2011). The purpose of this could be engagement towards emission reduction and advance the development of sustainability or contribute to preserve the environment. These values align with the widely held belief that individuals are willing to pay for maintaining or enhancing resources that they will never directly benefit from (Lewis & Tietenberg, 2020, p.85).

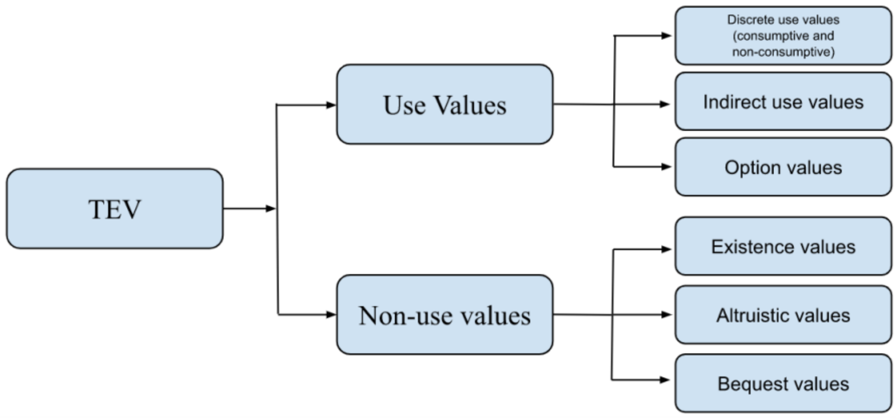

Figure 4.2: Total economic value divided in categories (Perman et al., 2011; Lewis & Tietenberg, 2020)

Environmental validation estimates the WTP for a good or service. Validation and decision involve a combination and balancing choices because spending money for one option means giving up other options (Segerson, 2017). The opportunity cost is an evaluation of the cost of the trade-off, which is fundamental by looking at the preferences of every respondent and the underlying factors that influence individual choices (Segerson, 2017). Using valuation techniques makes it possible to estimate these values and reveal the linkage between findings to find the total economic value. Non-use values are less tangible than use values because they come from motivations other than personal use. This suggests that the WTP for people may be lower than the minimum compensation needed to make up for people losing access to the environmental good (Lewis & Tietenberg, 2020, p. 80-87). The mechanisms of validating values are essential in developing and choosing the best practice survey method, which is described in chapter 6.

4.7 Random Utility Maximisation Model

The Random Utility Model is a theoretical framework used in economics to analyse individual decision-making under uncertainty. The model analyses discrete choices, assuming individuals make choices based on preferences. The utility derives from different options and attributes; these utilities are subject to random variation (Mariel et al., 2021).

The RUM assumes that an individual *i* chose an alternative j from a set of possible alternatives J based on the utility that the individual derives from each choice. The total utility denotes as where subscript *n* represents the individual; subscript *j* indicates the choosing alternative in chosen occasion *t.* The total utility ($\boldsymbol{U_{njt}}$) of alternative j for the individual *(n*) is composed of two parts: (1) A deterministic component ($\boldsymbol{V_{njt}}$) which is the utility of observable factors that are directly representative. The deterministic component represents the intrinsic utility of the alternative, which is assumed to be fixed and observable. (2) A random error term ($\boldsymbol{\varepsilon_{njt}}$) which captures the unobserved factors that affect the individual choices and is assumed to follow a specific distribution. It's a parameter that effect the utility that is not included in V_{njt} and is treated as a random variable. The random component denotes as a vector, $\boldsymbol{f(\varepsilon_n) = f(\varepsilon_{n11,}\ \varepsilon_{n22} \ldots .\varepsilon_{njt})}$, that represents the random joint effect, which shows the unobserved utility of each discrete choice (Train, 2009; Mariel et al., 2021; p.17). As a result, the usefulness of option *j* for person *n* can be expressed as:

$$\boldsymbol{U_{njt} = V_{njt} + \varepsilon_{njt}}$$

Equation 4.11: General RUM model

The deterministic utility, $\boldsymbol{V_{njt}}$, is a function of $\boldsymbol{X'_{njt}}$ which is a vector of attributes of alternative, and $\boldsymbol{S'_{njt}}$ represents a vector of attributes of the decisionmaker. The function can therefore be defined as:

$$\boldsymbol{V_{njt} = V(X'_{njt}, S'_{njt})}$$

Equation 4.12: The deterministic utility

We usually specify the deterministic utility as a linear function because of the assumption of linearity in the parameters, therefore we can decompose the utility function with a structural parameter as $\boldsymbol{V_{njt} = \beta X'_{njt}}$, where X'_{njt} is a vector of attributes of the goods, and is related to the alternative $j\beta$ which is parameters we are interested to estimate. The relationship β. The RUM model constructed in a way that makes the utilities

$$\boldsymbol{U_{njt} = \beta X'_{njt} + \varepsilon_{njt}}$$

Equation 4.13: The utility function with structural parameter

In our case, the following linear function provides the individual utility of an individual, *n*, for selecting the alternative i = 1, 2, from the choice set t = 1, 2, … 8 using the RUM approach.

$$\boldsymbol{U_{njt} = \beta_{10TWh}10TWh_{njt} + \beta_{20TWh}20TWh_{njt} + \beta_{30TWh}30TWh_{njt} + \beta_{40TWh}40TWh_{njt} + \beta_{700Turb}\,700Turb_{njt} + \beta_{1400Turb}\,1400Turb_{njt} + \beta_{2100Turb}\,2100Turb_{njt} + \beta_{cost}Cost_{njt} + \varepsilon_{njt}}$$

Equation 4.14: The random utility model

TWh_{njt} is the subscript for an increase in the output of renewable energy, $Turb_{njt}$ is the number of additional wind turbines, $Cost_{njt}$ is an increase in grid rent every year and ε_{njt} is an independent distributed standard Gumbel error term (Mariel et al., 2021, p.17). It is almost impossible to forecast preferences due to the random element, but using methods to analyse the maximum utility emphasizes the probability functioning, which chapter 5 reviews.

5. Methodology

This section of the thesis focuses on the theoretical part of identifying individual wind preferences, which includes measuring WTP and WTA.

5.1 Non-market valuation techniques

There are several non-market valuation techniques that seek to determine the economic values people place on goods and services that are not exchanged in markets. Within the literature, it is distinguished between two main methods: Revealed and Stated preferences (Segerson, 2017).

The revealed preference (RP) method uses behaviour connected to an environmental good or attribute to estimate preferences. For instance, it could be visits to a recreational site or purchasing a home and then inferring values from that behaviour. Within revealed methods, there are several techniques: Travel cost, Hedonics, Defensive behaviour, and Substitution methods (Segerson, 2017). The second method, stated preferences (SP), asks people questions about their preferences and values from their stated responses. Within stated preferences, there are two different techniques: contingent valuation (CV) and choice experiment (CE) (Segerson, 2017). Both techniques are based on survey data and make it possible to measure use and non-use values. In addition to this, the techniques can estimate willingness-to-pay (WTP) and willingness-to-accept (WTA). However, they do differ in their approach and design (Segerson, 2017). For example, RP only estimates use value based on observed behaviour, while SP can estimate use and non-use values (Perman et al., 2011). Our research focuses on non-use values, so the stated preference method is the best approach.

CV is a direct method that asks the respondents questions about their WTP or WTA for the environmental good. In the survey, a hypothetical scenario has been constructed, and respondents are asked to state their WTP or WTA for that scenario (Perman et al., 2011). After conducting the survey, the data is analysed to determine statistics of interest, which typically are mean and median WTP (Perman et al., 2011).

The discrete choice experiment (DCE) CE has become a widely used method of valuing environmental goods (Holmes et al., 2017). In contrast to CV, DCE is an indirect method. In DCE, respondents are presented with a variety of discrete alternatives. They are then instructed to choose the one they identify as their preferred alternative (Perman et al., 2011). One main issue with the DCE techniques is that the respondents might choose based on one attribute (Holmes et al., 2017). Another is that the respondents might need help being presented with multiple attributes, which can lead to mental shortcuts that might not reflect on their actual market choices (Holmes et al., 2017). In Chapter 5.2, about the survey, we will see how these issues are considered when designing the questionnaire.

When developing a DCE, there are two fundamental considerations. First, it is to identify who will be affected by changes in policy attributes and how they will be affected. Second, are the alternatives in the choice sets, and how many choice sets are needed? Usually, four to six choice sets are presented to the respondent; however, 16 or more are sometimes presented. It is important to remember the psychological strain for the respondent if presented with too many choice cards.

Choosing between CV and DCE is complex, and it needs to be clarified if one or the other is a better approach to value elicitation, but one needs to consider the most appropriate approach. The choice should consider the change being valued, the information needed, and the decision objective. The main difference between a CV and DCE is the scenario presentation. CV offers the possibility to estimate values when something cannot easily be defined in terms of attributes, while DCE can provide insight into the value of individual attributes that are wanted to support decision-making (Johnstone et al., 2017). If it does not make sense to frame some policy questions with attributes and marginal values of attributes that are not needed for policy analysis, then a CV method would be a better choice (Holmes et al., 2017).

5.2 The survey/questionnaire

Kantar has surveyed the research project LandValUse (project number 319917) to investigate the Norwegian population's preferences toward wind power. The targeted population was 18 years or older, and a total of 3 412 respondents completed the survey, which gives us a response rate of 31% when looking at the number of respondents who completed the survey. The survey is designed as a discrete choice experiment (DCE) where the primary purpose is to value environmental goods by asking participants to identify their preferred values. The respondents must consider several attributes before selecting their preferred alternative in the survey. The various attributes in the choice cards were:

Table 5.1: Attributes and levels

Attribute	Level
Increase in renewable energy without onshore wind power (in TWh)	10 20 30 40
Number of new onshore wind turbines	700 2 100 1 400
Area for new onshore wind turbines (in km^2)	No additional area for new wind turbines 294

	882 588
Reduction of greenhouse gas emissions from new onshore wind turbines (ton CO_2)	no additional reduction in CO_2 5 million 15 million 10 million
Value creation and number of new employments from new onshore wind turbines	No additional job creation and value creation 5 600 job creation (kr. 6,3 billion value creation) 16 800 job creation (kr. 18,9 billion in value creation) 11 200 job creation (12,6 billion in value creation)
Increase in yearly grid rent (in NOK)	Kr. 2 000,- Kr. 3 000,- Kr. 4 000,- Kr. 5 000,- Kr. 6 000,- Kr. 7 000, - Kr. 8 000, -

It is conducted as a randomized experiment, where the respondents are divided into four selections. The different selections are named “Baseline,” “Areal,” “Climate,” and “Value creation,” where “Baseline” contains all the attributes in the choice cards, and the others have selected attributes based on the themes.

The first questions in the survey required respondents to indicate which political cases they believed should be given top priority and how they believe the increase in power in Norway should be handled. The respondents were presented with information about the survey and that the government will use the results to make decisions concerning future license applications and further WPD. The information also states that the respondent's option is essential for these decisions.

The attributes are then explained to the respondents, starting with the increase in renewable energy apart from onshore wind power. In 2020, Norway produced 152 TWh of renewable energy, 92 percent hydropower, 7 percent wind power, and 1 percent classified as other. 80 percent of the power was used in Norway, while the rest was exported. The respondents also explained that energy production would increase in the coming years because of the increased population, new industries, and more electrical transportation. NVE lists possible sources of renewable energy, for example, more rain to the hydropower plants, solar power, offshore wind power, and efficient energy-saving measures that give excess power to use elsewhere.

The survey then presented the respondents with a map of the location of operating wind turbines and areas under development for the second attribute. At the time of the survey, there were 1 350 wind turbines in Norway, divided into 61 wind farms which produced 14 TWh. The respondents are presented with positive and negative externalities from a typical wind turbine in Norway. Examples are loss of nature, landscape, and animals, 7 150 tons of reduction in CO_2 from Europe (0,01 percent of Norwegian greenhouse gas emissions), Etc. In addition, the survey presented pictures of how WPD affects nature through new roads, deforestation, and rock excavation. Respondents were also asked if they have visited a wind farm and if their residence is less than 4 km from a wind farm.

The third attribute is the area for onshore wind power. Respondents are informed that the development of wind power results in the loss of nature and wildlife. One wind turbine requires approximately 800 meters of a construction road, which is 10 meters wide, an area of 0,42 square km, and 900 meters of power lines.

The respondent is then presented with the fourth attribute, which is: the reduction of greenhouse gas emissions from new onshore wind turbines (ton CO_2). It informs the respondents that wind power, over time, will contribute to replacing coal- and gas emissions in Europe, contributing to reduced GHG emissions. It is estimated that 10 TWh of Norwegian-produced wind power will reduce CO_2 emissions by 5 million tonnes per year in the r power sector, about 10 percent of Norway's total emissions.

The fifth attribute is value creation and the number of new employments from new onshore wind turbines. Further development of onshore wind power will create more jobs and increase value creation. It is estimated that one new wind turbine will give NOK 9 million in value creation. Last, the sixth attribute is presented. This is the yearly grid fee change for the respondent and their household. With increased renewable energy production, there will also be a cost to improve the Norwegian grid. The respondent is therefore asked to imagine that it will be financed by an increase in grid fee over the next five years and estimated to be between NOK 1 000 to NOK 8 000 per year per household.

As respondents are going to perform some trade-offs later in the survey, it is important that they have the information needed to do so. The respondents must be well informed about the current situation, explained earlier in this chapter, and it is crucial to get respondents to finish the survey (Mariel et al., 2021). This is to secure the validity of the research. We want the respondents to make informed choices, but with too much information, it can end up biasing people. On the other hand, by giving too little information, the respondent might end up using imagination and valuing the different types of "goods." The overall aim, environmental consequences with attributes, and the payment to be made are needed to be described and explained to the respondent (Mariel et al., 2021). Pre-testing is done to make sure there is enough information. Before this survey was launched to the respondents, there was a pilot survey with 400 respondents. A pre-test is highly recommended as it helps detect problems in the questionnaire/survey before collecting the answers to the full sample.

Later in the survey, the respondents had to choose between two alternatives in eight different choice cards. The respondents were divided into two blocks to randomize the choice cards giving the respondents a different order of the cards, minimizing the anchoring effect (Mariel et al., 2021). Alternative 1 always has an increase in renewable energy but with no further WPD. Alternative 2 also includes an increase in renewable energy but includes WPD. This gives an additional increase in renewable energy compared to alternative 1, along with additional turbines. The choice cards also always include an increase in grid fee as an attribute. After picking an alternative, they also need to answer how secure they were in their choice of alternative, from very sure to very insecure. To ensure compatibility, the respondents must care about the outcome, that the payment is coercive, and a single set of choice sets. As payment, a yearly increase in grid fee is used, which is coercive. Having such payment, there is no possibility of to free ride (Mariel et al., 2021).

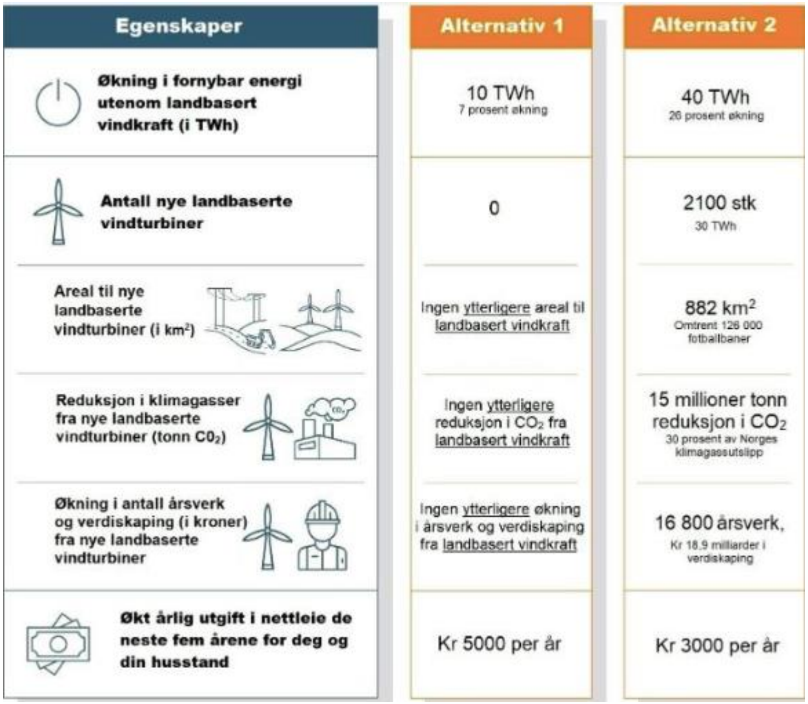

Figure 5.1 Example of a choice card – Baseline

At the end of the survey, the respondents are asked to answer several questions ranging from "never" to "always". The questions ranged from "The thought of climate change makes it hard for me to sleep" to "Protecting nature is more important than protecting economic growth". These questions are asked after the choice cards to avoid what is called context effects. If these questions were asked prior to the choice cards, the respondents might direct their attention to a specific attribute when answering questions later in the survey (Mariel et al., 2021).

At last, the respondents were asked socio-demographic questions such as gender, income, education, and age. It is recommended as best practice to have such questions at the end of the survey, as they are personal and considered sensitive information (Mariel et al., 2021). Some respondents might be hesitant to answer questions about their income and are often a question where we get a lot of missing values. One way to reduce this is to provide a list of income categories, as done in this survey.

The design of a DCE is crucial when it comes to the validity of the research. As we are going to do research on Norwegian households' preferences and WPT for wind power development it is important that our data is collected in a way that makes our study reliable. As presented in this chapter there are several aspects that needs to be considered when designing a DCE for validity.

5.3 Econometric Method

The multinomial logit model (MNL) is an econometric technique used to analyse the data for the discrete choice experiment. The model also considers the possibility that the respondents may have different preferences and priorities for the given attributes in random utility model (Train, 2009, p.34). Multinomial logit assumes that the respondent chooses the alternative that provides the individual with the most significant benefit due to the other characteristics of the alternatives and the participant's preferences (Train, 2009, p.35).

5.3.1 The multinominal logit model

The multinomial logit model (MNL) assumes that all individuals have homogenous preferences, and that the ε_{nit} affects the choices independent of the observable factor. The MNL simplifies the model by assuming that the joint density, $\boldsymbol{f(\varepsilon_n)}$, of unobserved utility is that each ε_{njt} is identical and independently distributed (i.i.d) with Gumbel (type 1 extreme value) (Train, 2009). Gumbel assume that every ε_{njt} have a specific distribution defined by $Var\left(\varepsilon_{njt}\right) = \frac{\pi^2}{6}$.

Each respondent has T = 24 options available to them. In the decision-making t where respondent, n, chooses scenario j of J = 2 alternatives regarding future wind power development where the outcome can be analysed by logit. The total probability function for individual *n* denotes as:

$$L_n = \Pi_t P_{nti}$$

Equation 5.1: The product of all probabilities for the chosen unobserved alternative in the MNL model

Where $P_{nti} = \frac{e^{V_{nti}}}{e^{V_{nti}}}$ and $V_{nti} = U_{nti} - \varepsilon_{nti}$. MNL assumes that the unobserved factors are independent of the observed factors, which may appear unrealistic considering many situations where unobserved factors, such as attitude and perceptions, can influence the observed attributes. The extension of the model allowing correlation between these factors is the mixed multinominal logit model (MMNL), which captures the complexity of choice behaviour and provides more accurate demand estimates.

The mixed multinominal logit (MMNL) builds on the multinominal logit model and allows individual heterogeneity in preferences and correlation among the unobserved factors. The MMNL model is better used for more profound research because it allows flexibility of unobservable random variation, unrealistic substitution patterns, and correlations in unobserved factors over time.

In contrast to MNL, the MMNL is not defined by the assumption about the joint density of unobserved utilityε_n. An MMNL model is any discrete choice model with choice probabilities of the form:

$$L_n = \int_{\beta} \Pi_t \, P_{nti} f(\beta_x | \theta) \, d\beta_x$$

Equation 5.2: The product of all probabilities for the chosen unobserved alternative in the MMNL model

The MMNL model is assuming that we have a vary distribution of coefficients, β_x, in the population given that the unknown density is $f(\beta_x|\theta)$, where θ is an underlying test parameter (Train, 2009). The assumption of β_x is to be normally or log-normally distributed overcoming the limitation of a multinominal logit model (Train, 2009, p. 138). MMNL would have been the best econometric method to use in our analysis. However, our computers could not run the simulations as we wanted due to lack of capacity. Chapter 7.2 Limitations will go through the limitations of time and resources. We have added a MMNL model with the full sample in Appendix 10 to illustrate how an MMNL model is estimated in Stata.

6. Empirical analysis

Empirical approaches establish a linkage between changes in the ecosystem and services and changes in the observable of people. Analyzing the people and behavior in the markets may help to understand the value of associated non-market goods.

6.1 Descriptive variables

In this section, we have selected specific variables from the dataset to answer our problem statement. The table below shows a short description and some summary statistics of each variable.

Table 6.1: Descriptive variables

Variables	Description	Type
Region	The problem is to see if preferences for wind turbines vary in different geographical areas in Norway. Before adjustment, the variable covers all 11 counties in Norway. We make it easier by recoding the variable into geographical areas to be able to interpret data more easily. The variable looks at the regions in Norway and is divided into five different geographical areas based on the 11 counties in Norway. The counties belonging to the region: "Northen Norway" = Troms and Finnmark, Nordland "Central Norway " = Trøndelag, Møre and Romsdal "Western Norway" = Vestlandet and Rogaland, "Eastern Norway" = Oslo, Innlandet and Viken "Southern Norway" = Vestfold and Telemark, Agder There is a significant dispersion with a standard deviation of 1.72.	Categorical variable – nominal level
Gender	The variable describes the gender of the respondent and is divided into two values, where man = 1 and woman = 2. Approximately 50/50 percent of females and men have responded to the survey; the standard deviation is 0.50, which indicates an even dispersion in gender.	Dummy variable
Age	The variable measures the respondent's age between 19 to 89 years old. Here we find that the average age for the regions is 49 years old, where the standard deviation is 0.28, which indicates a low dispersion. It could be because this age group is the majority in society or takes the time to answer this type of survey.	Continuous variable
Income	Households' total net income is a categorical variable. The distribution groups are; (1) Lower than NOK 600,000, (2) Between NOK 600,000 - 1,000,000, and (3) Higher than NOK 1,000,000" and (4) Don't want to answer in net income. 13 percent didn't want to answer, 27 percent stated group (1), 30 percent stated group (2) and 30 percent stated group (3). The mean of this variable is between	Categorical variable - nominal level

	distribution group (1) and (2). The standard deviation is 1.01, which indicates a large dispersion.	
Education	The level of education in Norway is a categorical variable that measured values from 1 to 6. These variables will examine whether there are significant differences in educational levels between the various regions. Thus, the lowest value is (1) = "Primary school (7 - 10 years)," and the highest level is (5) = "Ph.D." and (6) = "do not know". The standard deviation is 1.01, which means that the spread is high in the educational level of the respondents. Most respondents have completed upper secondary school, while some have a higher level of education.	Categorical variable – nominal level
Power_sources	Power_sources is a variable that asks the respondents how they prefer to cover future additional electricity needs by giving them 12 choices of power sources. The respondent could choose three options from the 12 choices. Figure 6.2.3 illustrate the respondents' preferences for meeting future energy needs. The mean is 9.7 and the standard derivation is 2.43, which indicates high dispersion.	Categorical variable – nominal level
Power_non_onshore	The variable measures how respondents feel about a general increase in power from the sources listed in Power_sources other than onshore wind power in Norway from 10 to 40 TWh. The target levels are divided into categories on an ordinal level where level (1) is very negative, (4) neutral, and (7) very positive. The mean is 5.25 and the standard deviation in the sample is 1.40, which indicates a large dispersion.	Categorical variable – ordinal level
See_turbine	The variable measures how often the respondent has seen wind power plants during leisure activities and is divided into categories on an ordinal level from 1 to 6. Category (1) is that they “do not see wind power plant at all”, (5) “25 or more days" and (6) “do not know”. The mean is 1.95 and the standard deviation is 1.26. The variable is recoded as a dummy variable to deepen the analysis of variation in WTP among the regions and is included in the making of two new variables exposed and nonexposed. The dummy variable	Categorical variable – nominal level Dummy variable

	is determined by value (1) seen wind power plants "25 or more days" and (0) "do not see wind power plants at all" during leisure activities. The mean is 0.06 and the standard deviation is 0.24.	
Affected	Affected is a variable examining whether households are directly affected by WPP. The target levels are divided into nominal level categories where Affected_(n) represents; (1) yes, we have housing where we can see wind turbines, (2) yes, we have cabin/holiday house where we can see wind turbines, (3) yes, we own land which is exposed to WPD, (4) yes, we are affected by wind turbines through work, (5) yes, we live nearby areas that could be exposed for WPD, (6) yes, we work with renewable energy, (7) no, we do not get affected and (8) we do not know. The mean is 6.57 and the standard deviation is 1.32. The variable is recoded into a dummy variable for grouping the households affected by wind turbines and those not. The variable has two values: (1) "the households are directly affected one or another way", and (0) "the households are not affected or do not know if they are directly affected" by WPP. The mean is 0.09 and the standard deviation 0.29, which indicates a low dispersion.	Categorical variable – nominal level Dummy variable
Distance_Turbine	Distance_Turbine is a dummy variable created to measure whether the home is less than 4 km from the wind power plant. The variable measures whether the household are exposed to wind farms as 4 km from their home/cabin/holiday home. The variable has two values, 1 if Distance_Turbine is "yes" and 0 if Distance_Turbine is "no". This variable is also created for our exposure analysis, where exposure is defined as if the respondent lives less than 4 km from a wind farm. The variable has a mean 0.12 and a standard deviation of 0.32 indicates low dispersion.	Dummy variable
Turbines700_ AFFECTED Turbines1400_ AFFECTED	Turbines(n)_AFFECTED is an interaction term, a product of the attribute called turbines and Affected. The n in turbines represents how many turbines there are in each choice situation, and Affected is a variable that defines if the households are directly affected by WPD. The interaction term will provide information on whether	Interaction terms

Turbies2100_ AFFECTED	people who are affected by wind turbines have different preferences for wind turbines.	
twh20_AFFECTED twh30_ AFFECTED, twh40_ AFFECTED	Twh(n)_AFFECTED is an interaction term, a product of the attribute called twh and Affected. Twh denotes an increase in renewable energy without onshore wind power (in TWh), where n is the amount of power. Affected is a variable that defines if households are directly affected by WPD. The interaction term will provide information on whether people who are affected by wind power have different preferences for renewable energy.	Interaction terms
Nonexposed	Nonexposed is also a dummy variable from See_turbine and Distance_Turbine. It has the value 1 if Distance_Turbine = 2 (do not live within 4 km), See_turbine = 0 and Distance_Turbine = 0. It helps us filter out the ones who are not exposed to wind power for our exposed vs. non-exposed analysis.	Dummy variable
Exposed	Exposed is a dummy variable that has the value 1 if See_turbine = 1 and if Distance_Turbine = 1, and 0 otherwise. If exposed is 1 then it means that the respondent is exposed to wind power either from living within 4 km from wind turbines or using the area "25 days or more" in a year	Dummy variable

6.2 Descriptive statistics

The total sample consists of 3 412 respondents, where 9 percent are from Northern Norway, 13 percent from Central Norway, 21 percent from Western Norway, 44 percent from Eastern Norway and 13 percent from Southern Norway. Table 6.2 introduces the socio-economic characteristics across the various regions.

Table 6.2: Socio-economic characteristics of the different regions

Observations	**Whole sample**	**Northern Norway**	**Central Norway**	**Western Norway**	**Eastern Norway**	**Southern Norway**
Respondents *(n)*	3 412	308	441	721	1 497	445

Gender ***(percentage)***	Male	50.06	48.70	46.71	51.32	50.70	50.11
	Female	49.94	51.30	53.29	48.68	49.30	49.89
Age (*mean***)**	18 – 89	49	50	47	49	49	51
Income ***(percentage)***	Lower 600 000	27.36	27.59	31.03	25.77	25.99	30.82
	Between 600 kr – 1 000 000 kr	29.48	27.93	29.06	28.26	29.89	31.53
	Above 1 000 000 kr	29.79	32.07	28.33	29.72	31.23	24.94
	Do not want to answer	13.37	12.41	11.58	16.25	12.89	12.71
Education ***(percentage)***	Primary school	5.00	6.17	4.57	4.04	4.92	6.52
	Upper secondary school	25.91	31.17	26.94	25.91	25.12	23.82
	Certificate of apprenticeship	21.58	25.00	22.37	24.23	17.81	26.74
	Bachelor's/master's degree	45.45	36.04	44.98	43.73	49.46	41.80
	Ph.d	1.15	0.97	0.68	0.84	1.68	0.45

Additionally, we have chosen the counties of Oslo and Rogaland to take a closer look at the study conducted by Dugstad et al. 2020. Of the total sample, 15 percent and 8 percent are from Oslo and Rogaland respectively. Table 6.3 illustrates the socio-economic characteristics of Oslo and Rogaland, where the t-test indicates that there are significant differences at 5 percent significance level ($p < 0.05$) in age and education (Appendix 1). Since Oslo and Rogaland are a part of Western and Eastern Norway, we assume that we'll find similarities in the samples.

Table 6.3: Socio-economic characteristics of Oslo and Rogaland

Observations		**Oslo**	**Rogaland**
Respondents *(n)*		515	284
Gender ***(****percentage****)***	Male	51.07	48.94
	Female	48.93	51.06
Age (*mean***)**	18 – 89	45	49
Income ***(****percentage****)***	Lower 600 000	29.67	23.13
	Between 600 kr – 1 000 000 kr	28.84	32.09
	Above 1 000 000 kr	28.63	28.36
	Do not want to answer	12.86	16.42
Education ***(****percentage****)***	Primary school	3.54	4.30
	Upper secondary school	19.09	26.52
	Certificate of apprenticeship	9.84	23.30
	Bachelor's/master's degree	65.55	45.52
	Ph.d	1.97	0.36

At 1 percent significant level, ANOVA represents significant differences among the regions in age and education (Appendix 2). The significant difference is more apparent between Eastern- and Northern Norway at the bachelor's and master's levels. This is also the case between Eastern- and Southern Norway at Ph.D. level. In terms of age, the average result shows that the middle age group between the regions is 49 years old.

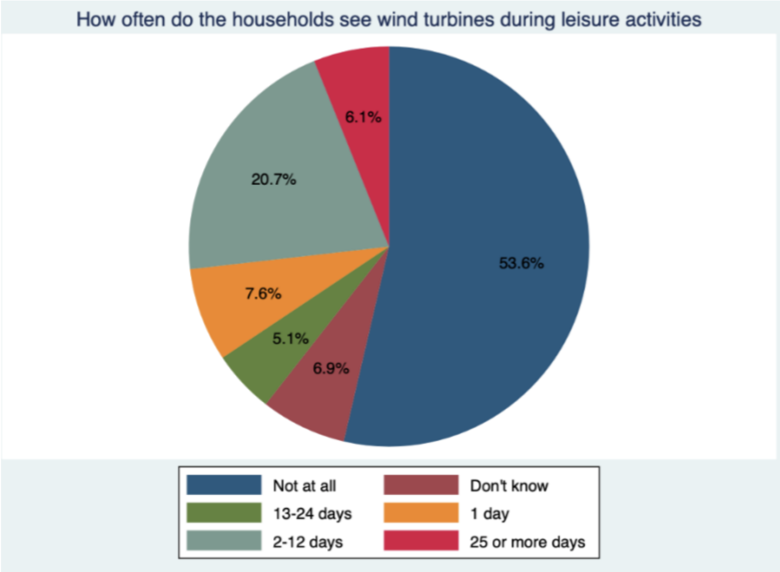

Figure 6.1: How often does the household see wind turbines during leisure activities.

Figure 6.1 shows that 53.6 percent of the respondents do not see wind turbines, while 6.1 percent and 5.1 percent answered that they see wind turbines for 13 to 24, and 25 or more days during leisure activities. The responses varied by region, with 60.0 percent and 64.9 percent of the Eastern- and Southern Norway samples responding that they do not see wind turbines. In contrast, 36.5 percent of respondents in Western Norway report not seeing any wind turbines.

Respondents were asked whether they were directly affected by the wind turbines. Only 15.7 percent of respondents from the full sample said that wind turbines directly influence them in some way. The remaining 84.3 percent said that they are not affected by them. Large parts of the sample are not directly affected by wind turbines, although it emerges that the answers differ significantly among the regions ($p < 0.01$) (Appendix 3). 90.2 percent and 87.9 percent of Southern- and Eastern Norway answered that they are not directly affected by wind turbines. In contrast, a lower percentage of 77.0 and 78.3 from Western- and Central Norway answered the same.

Participants were asked to answer whether they were directly exposed by WPD. 82 percent of the total sample answered “no” because their home is less than 4 km from wind power plants. The variance analysis illustrates no significant difference between the regions at a 5 percent significance level ($p > 0.01$) (Appendix 4). However, the answers vary slightly between the regions, where 13.86 and 12.57 percent of the respondents from Central- and Western

Norway answered that their home is less than 4 km from wind turbines, compared to Northern- and Eastern Norway, where it was 7.82 and 10.43 percent that responded the same. The descriptive statistics indicate differences in the degree of exposure and the degree of impact of wind turbines between the regions, where the deviations are most significant between Southeast Norway and Midwest Norway.

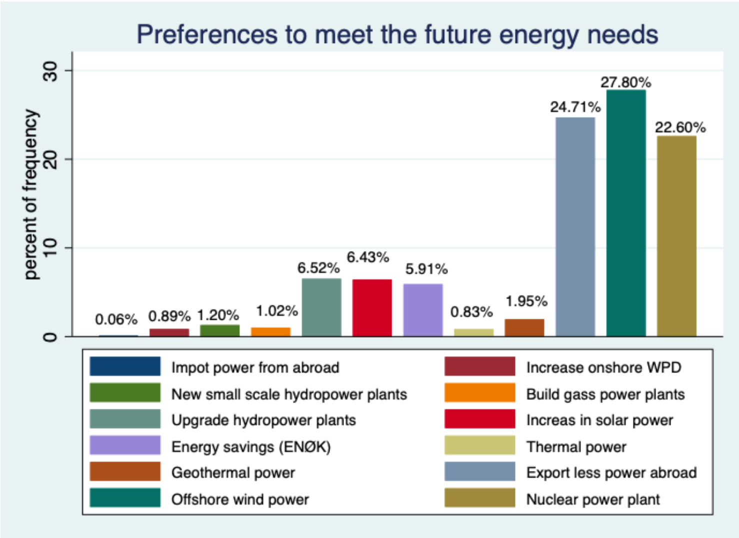

Figure 6.2: Preferences to meet future energy needs

Figure 6.2 shows that offshore wind power is highly preferred together with other energy sources such as exporting less abroad and nuclear power, while onshore wind power is one of the less preferred sources. Regarding preferences between the regions, there are no significant differences (p-value > 0.05) between the regions (Appendix 5).

Concerning how the respondents prefer to have their future power needs met, they were asked on a scale from 1 - 7 (very negative - positive) how they would like to see an increase in power production from the above sources other than onshore wind power. The results show that the sample prefers sources other than onshore wind power. The responses indicate that the respondent sees other energy sources as having more potential to cover future power needs. A p-value shows significant differences in the answers between the regions at a 5 percent significance level. Figure 6.3 shows the variations in the responses between the regions where Western Norway is very positive, while Northern Norway is more neutral towards other energy sources to meet future power needs.

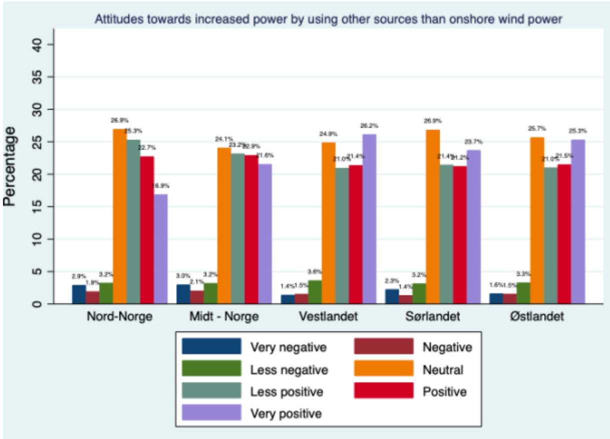

Figure 6.3: Attitudes toward increased power by using other energy sources than onshore wind power

6.3 Results

Several multinomial logit models (MNL) are estimated for our analysis of the geographical regions in Norway. Models were created for each region, and one with the full sample, with the designated names: NORTH, CENRAL, WEST, EAST, SOUTH and FULL. Further, the analysis examines a model with the entire sample and an interaction term which allows us to look even deeper into the WTP analysis for wind power development. The model is named AFFECTED as we are looking at how WTP changes when a household is affected by wind power.

Four models with different samples were created to test H3. One sample for exposed and one sample for non-exposed for each of the regions that are most exposed to wind farms: Central- and Western Norway (Table 6.6). EXPOSED_CENT and NONEXPOSED_CENT is the models estimated for Central Norway, while EXPOSED_WEST and NONEXPOSED_WEST is for Western Norway.

Finally, the models ROGALAND and OSLO were estimated to compare results with Dugstad et al. (2020). The models are presented in Table 6.7. In addition to this, calculating the average WTP from the results in Dugstad et al. (2020) and comparing it with ours gives us the opportunity to look at changes in WTP over time (Table 6.8).

In the FULL model, 44 percent chose alternative 1 which introduced an increase in renewable energy but no further WPD. 39 percent of the respondents chose alternative 2 which always has an increase in amount of additional wind turbines. The remaining 17 percent chose "do not know".

The estimated models discovered that all samples have the same signs on the coefficients at all the attribute levels, meaning they have equal qualitative preferences. The respondents have negative preferences for additional wind turbines and positive preferences toward an increase in renewale energy. The fee attribute is negative as people have positive marginal utility of income, which is expected in the results (Holmes et al., 2017). We have used the coefficients to calculate WTP for all our samples. Coefficients with significant levels and standard errors are presented in table A.1, A.2 and A.3 in the appendix.

6.3.1 Full sample and regions in Norway

We wanted to explore Norwegian households WTP for an increase in renewable energy and wind turbines to test hypothesis H1 and H2. A calculation of WTP for the turbine and TWh attributes on all levels has been done in all the models to test the hypothesis. The results are presented in table 6.4. The marginal WTP is calculated by taking the coefficient of the attribute (and level) divided by the coefficient of the fee attribute (cost).

$$MRS = -\frac{\partial v_{ik}/\partial z_i}{\partial v_{ik}/\partial y_i} = -\frac{\beta_i}{\lambda} = MWTP$$

Equation 6.1: Marginal WTP (Holmes et al., 2017, p. 162)

The results from FULL MNL presents that Norwegian households are willing to pay NOK 1 033, NOK 1 683 and NOK 2 204 for an increase of 20 TWh, 30 Twh and 10 TWh in renewable energy respectively. This indicates that people's WTP is increasing with the attribute level which is demonstrating internal scope sensitivity (Dugstad et al., 2021).

From our results, there are positive WTP for an increase in renewable energy in all the different regions in Norway. Table 6.4 illustrate that Eastern Norway is the region with the lowest WTP as the EAST model shows that for an increase of 40 TWh in renewable energy, people are willing to pay NOK 1 459. In the SOUTH model people have the highest WTP with NOK 2 544 and NOK 1 929 for an increase of 40 TWh and 20 Twh of renewable energy respectively. For an increase of 30 TWh, the WEST model has the highest WTP with NOK 2 076.

Comparing WTP between the different models can be done by comparing the confidence interval[1]. If the confidence intervals of the specific WTP in the models are overlapping, then WTP is less likely to be statistically different (Mariel et al., 2021). Examining confidence intervals for WTP, all models have overlapping confidence intervals for an increase in renewable energy, indicating that there is no significant difference among the regions.
The estimated models differ in size as presented in Table 6.4, as the numbers of observations are unequal. We have therefore looked at Pseudo R-squared in all our models, finding low results indicating a bad fit for our models. However, this is normal when estimating MNL models compared to MMNL as MNL are stricter when it comes to assumptions. The ROGALAND model does have a slightly higher Pseudo R-squared, however, we are unable to conclude that any of them are more superior than the others.

Table 6.4: WTP and 95% confidence intervals for full sample and the different regions in Norway

Sample	**Attributes and levels**	**WTP *(S.e.)***	**95% conf. interval**	
FULL	20 TWh	1 033.07 *(137.19)*	764.18	1301.96
	30 TWh	1 683.24 *(190.28)*	1 310.30	2 056.19
	40 TWh	2 203.63 *(236.61)*	1 739.87	2 667.38
	700 turbines	-2 135.48 *(159.35)*	-2 447.80	-1 823.15
	1 400 turbines	-3 084.81 *(169.17)*	-3 416.38	-2 753.24
Obs = 45 438	2 100 turbines	-3 806.41 *(176.40)*	-4 152.153	-3 460.67
NORTH	20 TWh	913.15 *(428.78)*	72.74	1 753.56
	30 TWh	787.09 *(588.99)*	-367.30	1 941.49
	40 TWh	1 719.94 *(739.99)*	269.58	3 170.30
	700 turbines	-2 147.09	-3 125.69	-1 168.49

[1] There are other tests that are possible to perform when comparing WTP, who are considered more favorable. Some are for example the Poe test (Mariel et al, 2021) , the delta method and Krinsky-Robb method (Champ et al. 2017).

		(499.29)		
	1 400 turbines	-2 661.46	-3 682.15	-1 640.77
		(520.77)		
Obs = 3 974	2 100 turbines	-3 287.89	-4 364.09	-2 211.69
		(549.09)		
CENTRAL	20 TWh	1 176.39	293.09	2 059.68
		(450.67)		
	30 TWh	1 939.10	712.13	3 166.08
		(626.01)		
	40 TWh	1 896.45	397.31	3 395.58
		(764.87)		
	700 turbines	-2 285.11	-3 311.27	-1 258.95
		(523.56)		
	1 400 turbines	-3 551.16	-4 660.94	-2 441.37
		(566.22)		
Obs = 5 844	2 100 turbines	-4 065.38	-5 205.91	-2 924.86
		(581.91)		
WEST	20 TWh	857.64	294.25	1 421.03
		(287.44)		
	30 TWh	2 076.08	1 271.20	2 880.95
		(410.65)		
	40 TWh	2 265.29	1 276.53	3 254.06
		(504.48)		
	700 turbines	-2 849.84	-3 526.16	-2 173.53
		(345.06)		
	1 400 turbines	-4 260.75	-5 029.23	-3 492.27
		(392.08)		
Obs = 9 576	2 100 turbines	-4 865.41	-5 667.49	-4 063.32
		(409.23)		
EAST	20 TWh	616.51	-140.98	1 374.01
		(386.48)		
	30 TWh	610.29	-438.43	1 659.02
		(535.07)		
	40 TWh	1458.73	153.44	2 764.02
		(665.97)		
	700 turbines	-2 285.11	-3 180.46	-1 389.76
		(456.81)		
	1 400 turbines	-2 556.35	-3 476.13	-1 636.57
		(469.28)		
Obs = 5 948	2 100 turbines	-3 465.79	-4 431.82	-2 499.75
		(492.88)		
SOUTH	20 TWh	1 212.87	814.21	1 611.53
		(203.40)		
	30 TWh	1 919.30	1 369.06	2 469.55
		(280.74)		
	40 TWh	2 544.09	1 858.80	3 229.37
		(349.64)		
	700 turbines	-1 702.30	-2 158.14	-1 246.46
		(232.57)		
	1 400 turbines	-2 650.14	-3 125.39	-2 174.89

		(242.47)		
Obs = 20 096	2 100 turbines	-3 420.47 *(251.26)*	-3 912.93	-2 928.00

Table 6.4 also presents the result for WTP regarding additional turbines. In the FULL model, people are willing to pay NOK 2 135, NOK 3 085 and NOK 3 806 to avoid 700, 1 400 and 2 100 additional wind turbines respectively. From the models dedicated to the different regions, WEST has the highest WTP to avoid WPD at all levels of additional wind turbines. SOUTH is the model with the lowest WTP with NOK 1 702, NOK 2 650, NOK 3 420 to avoid 700, 1 400 and 2 100 turbines, respectively. All the regions in Norway have a negative WTP which implies that people are experiencing negative utility with additional wind turbines.

There are statistical differences in WTP for all levels of turbines between the WEST and the SOUTH models, with WEST having a higher WTP to avoid additional turbines than SOUTH by comparing the confidence intervals. In addition to this, there is no overlapping of confidence interval between WEST and EAST for an additional 1 400 turbines, which also indicates a significant difference between the two regions. It was estimated that people are willing to pay NOK 4 260 to avoid 1 400 turbines in the WEST model, while EAST are willing to pay NOK 2 556. Some confidence intervals for WTP only have a small overlap, which can indicate some significance, but overall, the respondents experience negative utility with the increase in wind turbines and generally there is not much of a difference between the regions in Norway.

Expanding our analysis an additional model was estimated, which included an interaction term in the full sample giving us the model named AFFECTED. The respondents were asked if they or anyone in their household is affected by wind power. Using the model with the full sample and an interaction term makes it possible to see if there is a difference in WTP for those who say they are affected. Table 6.5 presents the AFFECTED model which shows that people who are affected by WPD have a lower WTP to avoid additional wind turbines than the rest of the sample. In addition, the model estimates negative preferences to an increase in renewable energy. However, results from the MNL model with interaction term show that none of the results are significant, presented in Appendix 9. Therefore, we cannot conclude that being affected by wind turbines has a negative impact on people’s utility. The results are not significant, and we do not test this with overlapping confidence intervals.

Table 6.5: WTP and 95% confidence intervals for the estimated AFFECTED model

Sample	**Attributes and level**	**WTP**	**95% Conf. interval**	
AFFECTED	20 TWh	1 110.25 *(147.59)*	820.96	1 399.54
	30 TWh	1 753.58 *(204.29)*	1 353.16	2 153.99
	40 TWh	2 313.83 *(254.07)*	1 815.85	2 811.81
	700 Turbines	-2 011.14 *(170.72)*	-2 345.76	-1676.53
	1 400 Turbines	-2 974.13 *(179.88)*	-3 326.70	-2 621.55
	2 100 Turbines	-3 775.26 *(187.68)*	-4 143.12	-3 407.41
	20 TWh x AFFECTED	-330.50 *(462.37)*	-1 236.75	575.73
	30 TWh x AFFECTED	-208.48 *(644.65)*	-1 471.98	1 055.02
	40 TWh x AFFECTED	-640.39 *(796.51)*	-2 201.54	920.75
	700 Turbines x AFFECTED	-845.66 *(540.32)*	-1 904.68	213.35
	1 400 Turbines x AFFECTED	-733.22 *(563.59)*	-1 837.85	371.41
Obs = 44 418	2 100 Turbines x AFFECTED	-264.02 *(559.36)*	-1 360.36	832.32

6.3.2 Exposed and non-exposed to wind power in Central- and Western Norway

As we wanted to explore the differences between those exposed to wind farms and those not, we estimated four new MNL models. Defining exposed as (1) if the respondent's house is located less than 4 km from a wind farm and (2) if the respondent uses areas for activities where they can see wind farms (more than 25 days per year). As Central- and Western Norway are the leading regions in Norway where most people inform that they are exposed to wind power, we chose to look at these two specific regions. EXPOSED_CENT and NONEXPOSED_CENT is the models we estimated for Central Norway and EXPOSED_WEST and NONEXPOSED_WEST is the models for Western Norway.

Respondents in EXPOSED_CENT model are willing to pay NOK 4 826 to avoid an additional 2 100 turbines while NONEXPOSED_CENT are willing to pay NOK 3 981 to avoid the same number of turbines. Further, finding that EXPOSED_CENT experiences more negative utility for an additional 700 and 1 400 turbines compared to

NONEXPOSED_CENT. Those in EXPOSED_CENT are willing to pay NOK 4 530 and NOK 4 779 for an additional 700 and 1 400 turbines respectively, while NONEXPOSED_CENT is willing to pay NOK 2 015 to avoid an additional 700 turbines and NOK 3 543 for 1 400 turbines.

According to our results, there is a different trend in Western Norway. In the NONEXPOSED_WEST model people are willing to pay more to avoid further wind power development than EXPOSED_WEST, but only for an additional 1 400 and 2 100 turbines. In EXPOSED_WEST model we find that people are willing to pay NOK 4 558 to avoid an additional 2 100 turbines compared to NONEXPOSED_WEST model who are willing to pay NOK 4 937.

While NONEXPOSED_WEST experiences a greater negative utility for the 1 400 and 2 100 turbine level, they are willing to pay NOK 2 529 for additional 700 turbines while the EXPOSED_WEST model is willing to pay NOK 3 900 to avoid the same number of wind turbines. However, when comparing the confidence intervals in all the models, EXPOSED_CENT, NONEXPOSED_CENT, EXPOSED_WEST, and NONEXPOSED_WEST, we find that all the intervals are overlapping, indicating no significant difference in WTP between exposed and non-exposed people in the two regions.

Table 6.6: WTP non-exposed and exposed in Western- and Central Norway WTP and 95% confidence intervals for EXPOSED_CENT, NONEXPOSED_CENT, EXPOSED_WEST and NONEXPOSED_WEST.

Sample	**Attribute and level**	**WTP (S.e.)**	**95% conf. Interval**	
EXPOSED_CENT	700 turbines	-4 530.10 (2 164.07)	-8 771.61	-288.60
	1 400 turbines	-4 778.60 (2 209.00)	-9 108.17	-449.03
Obs = 1 122	2 100 turbines	-4 825.70 (2 216.70)	-9 170.36	-481.04
NONEXPOSED_ CENT	700 turbines	-2 015.42 (524.99)	-3 044.38	-986.459
	1 400 turbines	-3 543.11 (574.68)	-4 669.46	-2 416.75
Obs = 4 320	2 100 turbines	-3 981.40 (586.78)	-5 131.48	-2 831.32
EXPOSED_WEST	700 turbines	-3 900.02 (880.31)	-5 625.41	-2 174.63
	1 400 turbines	-4 152.04 (927.69)	-5 970.28	-2 333.80

Obs = 2 182	2 100 turbines	-4 558.36 (984.12)	-6 487.21	-2 629.52
NONEXPOSED_ WEST	700 turbines	-2 529.08 (416.33)	-3 345.09	-1 713.07
	1 400 turbines	-4 202.81 (473.92)	-5 131.68	-3 273.95
Obs = 6 336	2 100 turbines	-4 937.66 (496.27)	-5 910.34	-3 964.97

6.3.3 Oslo vs. Rogaland

As a part of our research, we wanted to find out if there are any similarities between our findings and Dugstad et al. (2020) research done on WTP in Rogaland compared to Oslo. According to our results in Table 6.7, the ROGALAND model has a higher WTP than the OSLO model for an additional 2 100 turbines. ROGALAND is willing to pay NOK 5 037 compared to OSLO with NOK 2 838.

ROGALAND is also following this trend when looking at an additional 700 and 1 400 turbines. In the ROGALAND model, people are willing to pay NOK 3 235 and NOK 4 673, while in the OSLO model, they are willing to pay NOK 1 244 and NOK 2 014 for 700 and 1 400 turbines, respectively. Looking at their confidence interval to compare WTP within regions, there are no overlapping intervals for either turbine attribute level. This concludes that there is a significant difference in the WTP between ROGALAND and OSLO in Norway.

Looking at the different regions WTP for an increase in TWh, we find similarities between ROGALAND and OSLO respondents. Both regions have a positive WTP, meaning they are willing to pay more in yearly grid fees for more renewable energy. For an additional 20 TWh, ROGALAND is willing to pay NOK 888, while OSLO is willing to pay NOK 1 277. For an increase of 30 TWh, people are willing to pay NOK 1 931 and NOK 1 522 in the ROGALAND and OSLO models, respectively. Finally, with an increase of 40 TWh, ROGALAND has a WTP of NOK 2 359, while in the OSLO model, people are willing to pay NOK 2 186. All the confidence intervals overlap, meaning no statistical difference between the OSLO and ROGALAND models regarding WTP for an increase in renewable energy.

Table 6.7: WTP and 95% confidence intervals for Oslo and Rogaland

Sample	Attributes and levels	WTP	95% conf. interval	
OSLO	20 TWh	1 276.71 (346.03)	598.49	1 954.94
	30 TWh	1 522.07 (468.16)	604.47	2 439.66
	40 TWh	2 186.44 (582.26)	1 045.22	3 327.66
	700 turbines	-1 244.48 (395.45)	-2 019.55	-469.41
	1 400 turbines	-2 014.58 (400.55)	-2 799.66	-1 229.51
Obs = 7 034	2 100 turbines	-2 838.58 (411.74)	-3 645.58	-2 031.59
ROGALAND	20 TWh	888.36 (408.91)	86.90	1 689.82
	30 TWh	1 930.78 (576.21)	801.42	3 060.13
	40 TWh	2 358.75 (713.99)	959.35	3 758.15
	700 turbines	-3 235.43 (501.12)	-4 217.62	-2 253.23
	1 400 turbines	-4 673.05 (572.14)	-5 794.44	-3 551.67
Obs = 3 754	2 100 turbines	-5 036.68 (575.45)	-6 164.56	-3 908.80

Dugstad et al. (2020) found in their research that respondents from Rogaland accept compensation of NOK 498,55 per month (NOK 6 544 per year, adjusted for inflation) with an additional 3 000 turbines. In our research, respondents from Rogaland are willing to pay NOK 5 036 a year to avoid 2 100 turbines which we presented in Table 6.7. As we want to compare WTP over time, we have calculated the average yearly WTP for one turbine from Dugstad et al. (2020) findings in our findings for the ROGALAND and OSLO models for all levels of turbines. This has also been done with confidence intervals to test whether significant differences exist between the counties. The annual average WTP for an increase in wind turbines at different levels is presented in Table 6.8. All the numbers in the Dugstad et al. (2020) study is adjusted for inflation in the table below, from 2019 to 2022 since we compare them to our data from 2022.

Table 6.8: comparison of average WTP and 95% conf. interval from findings in Dugstad et al (2020) and our findings

Sample	**Attribute and level**	**Average WTP**	**Average 95% conf. Interval**	
Oslo (Dugstad et al.)	700 turbines	-1 778	-3 133.14	-423.15
	1 400 turbines	-3 556	-6 266.28	-846.31
Obs = 3 360	2 100 turbines	-5 334	-9 399.42	-1 269.46
Rogaland (Dugstad et al.)	700 turbines	-3 106	-4 610.71	-1 601.60
	1 400 turbines	-6 212	-9 221.43	-3 203.20
Obs = 3 208	2 100 turbines	-9 318	-13 832.14	-4 804.80
Oslo	700 turbines	-1 540	-1 906	-934.27
	1 400 turbines	-3 080	-3 812.40	-1 868.54
Obs = 7 034	2 100 turbines	-4 620	- 5 718.59	-2 808.82
Rogaland	700 turbines	-2 408	-3 489.22	-2 145.24
	1 400 turbines	-4 816	-6 978.44	-4 290.47
Obs = 3 754	2 100 turbines	-7 224	-10 467.65	-6 435.71

From our calculations, people from Oslo in Dugstad et al. (2020) are willing to pay NOK 1 788 to avoid an additional 700 turbines, while in our Oslo model, we find people are willing to pay NOK 1 540. For the other turbine levels, the Dugstad et al. (2020) Oslo model is willing to pay NOK 3 556 and NOK 5 334 to avoid 1 400 and 2 100 turbines, respectively. Our Oslo model has lower WTP values, NOK 3 080 for 1 400 turbines and NOK 4 620 for 2 100 turbines. The results present overlapping confidence intervals on all attribute levels, which concludes that there is no significant difference between Dugstad et al. (2020) Oslo model and our Oslo model.

The Rogaland model in Dugstad et al. (2020) also has a negative trend for additional wind turbines. People in Rogaland are willing to pay NOK 3 106, NOK 6 212 and NOK 9 318 to avoid 700, 1 400, and 2 100 turbines, respectively. In our Rogaland model, there is a lower WTP to avoid additional wind turbines. People are on average willing to pay NOK 2 408 to avoid 700 turbines. Their WTP for avoidance increases to NOK 4 816 when we look at an additional 1 400 turbines and NOK 7 224 for 2 100 turbines. Comparing the confidence intervals, there are overlapping confidence intervals as there were in the Oslo comparison. This means that there is no significant difference between the two Rogaland models.

7. Discussion

This chapter discusses focuses on discussing the research questions and hypotheses developed and tested in this study. It will give a clear overview of the key results, and the discussion will also include a comparison of previous studies that we have gone through in our literature review in chapter three. The chapter will also take on limitations, environmental policy recommendations, and future research.

7.1 Research Questions and Hypothesis

Research question 1 (RQ1) seeks to find how Norwegian households' WTP for wind power development varies among the different regions in Norway. H1 and H2 are developed for the discussion, jointly with the literature review and the results, to answer RQ1.H1 states that people have positive WTP to increase the use of renewable energy. The estimations from MNL show that Norwegian households, in general, are willing to pay for increasing additional TWh in renewable energy. Even though the total sample has a positive WTP, some variations exist between the regions. The EAST model has the lowest WTP (NOK 1 459), and SOUTH has the highest WTP (NOK 2 544) for an increase of 40 TWh in renewable energy among the regions. Since the results have overlapping confidence intervals, we cannot conclude that the differences observed in WTP are significant. This suggests that WTP is not influenced by coincidences or bias in the sample, which helps to strengthen the validity and robustness of the study. One must be careful in generalizing the results from average measures because there may still be differences among individual preferences in WTP within the regions.

A range of literature support H1, where the findings from Lindhjem et al. (2019), Dugstad et al. (2020), and Zerrahn (2017) indicate that people generally are positive toward increasing the use of renewable energy. In addition, the report from Statkraft (2022) found that European consumers have a positive WTP towards renewable energy, where 69 percent of the respondents stated that renewable energy should be prioritized. The studies do not say definitive the explanatory factors of why people are positive towards renewable energy. However, by rationality, it could be that people want to contribute to reducing emissions and do their part to mitigate climate change. Another reason for a positive preference for additional renewable energy could be to improve energy security. A range of literature support H1, where the findings from Lindhjem et al. (2019), Dugstad et al. (2020), and Zerrahn (2017) indicate that people generally are positive toward increasing the use of renewable energy. In addition, the report from Statkraft (2022) found that European consumers have a positive WTP towards renewable energy, where 69 percent of the respondents stated that renewable energy should be prioritized. The studies do not say definitive the explanatory factors of why people are positive towards renewable energy. However, by rationality, it could be that people want to contribute to reducing emissions and do their part to mitigate climate change. Another reason for a positive preference for additional renewable energy could be to improve energy security.

According to H2, people have a negative WTP for the increased development of additional wind turbines. Our results show that Norwegian households experience negative utility and are willing to pay to avoid WPD. Generally, the result shows little difference due to minor or no overlapping of confidence interval among the regions in Norway. There are statistically significant differences between WEST and SOUTH for an additional 1 400 wind turbines and for all levels of turbines between WEST and EAST. The WEST model has the highest WTP (NOK 2 850 for 700 turbines, NOK 4 261 for 1400 turbines, NOK 4 865 for 2100 turbines), and SOUTH has the lowest WTP (NOK 1 702 for 700 turbines, NOK 2 650 for 1400 turbines, NOK 3 420 for 2100 turbines) to avoid all levels of additional wind turbines.

In various literature, has been detected low acceptance in the samples and illustrates that people are willing to pay to preserve the areas in nature due to the externalities of wind energy (Dugstad et al., 2020; García et al., 2016; Dugstad et al., 2023; Meyerhoff et al., 2010; Brennan & van Rensburg, 2016; Zerrahn., 2017). It is known that there are more wind turbines in Western Norway compared to Southern and Eastern Norway, which could explain why Western is willing to pay more to avoid them. However, the topic of exposure to WPD is explored more in research question two.

We also added an interaction term to our full sample model to determine if people affected by wind power had different WTP for an increase in renewable energy and turbines. We found no significant result from our AFFECTED model with the interaction term. Therefore, we cannot conclude that our results, which show a lower WTP to avoid WPD and a lower WTP to increase renewable energy, support our initial thought that people affected by wind power had a higher WTP to avoid.

Even though we did not find any significant results with the interaction term in the AFFECTED model, we wanted to see if there were any significant results if we looked at people who were exposed and not exposed. This is explored in our second research question, “How does people’s exposure to wind power affect people’s WTP for additional wind power development?” For this research question, we developed H3: People from Central- and Western Norway who are exposed to WPD differ from non-exposed individuals in their WTP for more WPD.

Our findings on the EXPOSED_CENT model show that people are willing to pay more to avoid additional wind turbines than the NONEXPOSED_CENT model. There is a different trend in the EXPOSED_WEST and NONEXPOSED_WEST models, as NONEXPOSED_WEST are willing to pay more to avoid an additional 1 400 and 2 100 wind turbines than EXPOSED_WEST. However, all the confidence intervals are overlapping, indicating no statistical difference. Therefore, we cannot conclude that there is a difference in WTP between exposed and non-exposed regions. This is in contrast with the research done by Ladenburg et al. (2013), Ladenburg (2010), García et al. (2016), and Brennan & van Rensburg (2020), who found that exposure to turbines leads to more negative preferences compared to those who do not. However, they all focus on differences between distinct regions, one being exposed and the other who is less exposed. Our research question is about exposed and non-exposed within an already exposed region. While we find no difference, we see that both samples have a negative preference toward WPD. One possible explanation that there are no significant differences might be a combination of exposure that leads to a negative WTP for further WPD, and those who are not exposed find themselves negative to further WPD because of strong place attachment (Brennan & van Rensburg, 2020; Dugstad et al., 2023; Ek & Persson, 2014), resulting in more similar negative WTP. Our findings are consistent with those in the literature because onshore wind farms are typically situated in areas of the nearby population's culturally significant natural landscape. The externalities that come with wind turbines affect these areas' value, which people consider a welfare loss.

It is worth mentioning that EXPOSED_CENT shows large confidence intervals and standard errors, indicating broad differences in opinions within the sample. This comes from a smaller sample size in EXPOSED_CENT compared to NONEXPOSED_CENT. If we had more similar sample sizes, we would get smaller confidence intervals, affecting our answer to our hypothesis.

Our last research question is, “Are there any similarities in our findings compared to the research done by Dugstad et al. (2020)?” From this, we have two hypotheses (H4 and H5) we wanted to test. H4: People from Rogaland have a higher WTP to avoid wind power development than people from Oslo. H5: People are more negative to wind power development now compared to previous years.

For H4, our findings are consistent with the findings in Dugstad et al. (2020). Our results also find that people in Rogaland, ROGALAND model, are willing to pay more to avoid additional wind turbines at all levels compared to our OSLO model, supporting H4. We test by looking at overlapping confidence intervals, and we find no overlapping at any level. This concludes that there is a significant difference between OSLO and ROGALAND’s WTP regarding additional wind turbines. Our results indicate that regions more experienced with WPD are willing to pay more to avoid WPD. This is also argued for by Ladenburg et al. (2013), Ladenburg (2010) García et al. (2016), Brennan & van Rensburg (2020). Reasons for this could be because of more experience with the externalities from WPD and more people who encounter wind turbines compared to a region that is not exposed.

We found that an increase in TWh has a similar WTP in our studies between OSLO and ROGALAND, compared to Dugstad et al. (2020). All the confidence intervals overlap, suggesting no significant difference between the two regions, and both are willing to pay for an increased amount of TWh. Dugstad et al. (2020), their results present a significant difference between the WTP of an increase in renewable energy, where Oslo residents are willing to pay more compared to Rogaland residents. While our results differ from Dugstad et al. (2020), we see similarities as both regions are willing to pay for an increase in renewable energy. The reason for our findings that indicate no difference can be an increased focus on renewable energy, the need for it and that people generally want an increase in renewable energy (Statkraft, 2022), minimizing the difference between regions. Another reason might be energy security, a central topic after the Russian invasion of Ukraine early in 2022.

Answering H5, we looked at Dugstad et al. (2020) results to see if there are any differences in

WTP over time. We found by comparing confidence intervals that there is an overlap between the Oslo models. Therefore, we cannot conclude that there is a significant difference over time in WTP in Oslo. The same goes for the Rogaland models. In the comparison between Dugstad et al. (2020) Rogaland model and our Rogaland model, we only find overlapping confidence intervals. Therefore, we cannot conclude that there is a difference in Rogaland's WTP over time. An important note is that our studies have data only three years apart. Dugstad et al. (2020) collected their data in April 2019, while our data is from April 2022. Between these two periods, there were no new license applications under review as it was shut down in 2019 (April) by the government. They started the license applications again after our data was collected. The biggest ongoing construction of WPD in 2019 was the Bjerkreim wind farm in Rogaland. In 2022 there was no construction of wind power in Rogaland. No other wind warms were in Rogaland's planning stage at the time in 2022, and no construction/planning in Oslo in 2019 or 2022 (NVE, 2023b). Wolsink (2007) refers to a U-shaped pattern that illustrates that acceptance of WPD changes over time to more positive after some time after construction. As our data is collected only 3 years apart, we are not surprised that our results are similar to Dugstad et al. (2020) Rogaland and Oslo as it is such a short period of time. Another critical difference is that Dugstad et al. (2020) use the MMNL model while we use the MNL model to estimate our results which also affects our comparison.

7.2 Limitations

With our studies, there are some limitations that we want to address. First, our study uses the multinomial logit model as our econometric model to estimate the results. As mentioned in Chapter 5, a mixed multinomial logit model builds on the MNL model and allows individual heterogeneity in preferences and correlation among unobserved factors. The MMNL model is better used for more profound research because it allows flexibility of unobservable random variation, unrealistic substitution patterns, and correlations in unobserved factors over time. However, our research used the MNL model because of time limitations and computer capacity.

Second, since we used the MNL model, this also affects our Pseudo R-Square. The Pseudo R-square is very low throughout the models, indicating a poor fit. However, this is more normal when estimating MNL models compared to MMNL models. An MMNL model would be more accurate and valid (Mariel et al., 2021). With that being said, we have looked at internal scope sensitivity, which acts as a validity test. In Chapter 5.2, about the survey, we have touched upon several important factors when conducting a DCE, strengthening the validity of this research.

Third, to test differences in WTP, there are several methods to choose from. In this research, we used an overlapping confidence interval test to test whether the differences in WTP were significantly different between the models. Other tests that can be used for such a purpose are the Poe test (Mariel et al., 2021), the Krinsky-Robb method, and the Delta method (Holmes et al., 2017). However, the overlapping confidence intervals method is used in research and suggested by Mariel et al., (2021) as a method. Our results may differ from other research that has conducted the other tests, but we did not perform other tests because of time limitations.

Finally, we compared our study with Dugstad et al. (2020) for comparison over time. Their data was collected in 2019, and ours in 2022. As there is not much research about WTP in Norway for additional WPD, we could not find any studies further back in time. This limits our comparison to three years, which is a relatively short time, and we could not conclude any difference in WTP over time for WPD.

8. Concluding Remarks

This master's thesis looks at Norwegian households' preferences and WTP focusing on different geographical areas in Norway and the degree of exposure to wind turbines. Jointly with results and previous studies, we can conclude to answer the research questions that we have reviewed.

Results show that people, in general, are positive about an increase in renewable energy and that there is no significant difference between the regions in Norway. People are willing to pay at all attribute levels. In contrast, people experience a negative level of utility from the expansion of additional wind turbines and are willing to pay to avoid them. The result illustrates significant differences in WTP between Western- and Southern Norway. Western Norway is willing to pay the highest with NOK 2 850, NOK 4 261 and NOK 4 865 for 700, 1 400 and 2 100 additional wind turbines. While Southern Norway has the lowest WTP, with NOK 1 702, NOK 2 650 and NOK 3 420 for 700, 1 400, and 2 100 additional wind turbines, respectively. There is low acceptance in the sample, which illustrates that people are willing to pay to preserve nature due to the negative externalities of wind power.

Regarding the exposure to wind farms and how this affects people, we found overlapping confidence intervals between nonexposed and exposed in Central- and Western Norway. These findings do not follow previous studies and could be because our research focuses on exposed and non-exposed within exposed regions. This contrasts with other studies because they all focus on differences between regions, one exposed and the other not exposed.

The results are similar to the findings of Dugstad et al. (2020), which show significant differences in WTP between Rogaland and Oslo. People from Rogaland are willing to pay more to avoid additional WPD than Oslo. The reasoning could be due to more experience with negative externality from WPD. Regarding an increase in renewable power, we found greater similarities in the WTP between Rogaland and Oslo than in Dugstad et al. (2020) who find a significant difference. An explanation for why we do not find any significant differences could be that people have had an epiphany about the climate change problem or the need for energy security. A comparison over time concludes that there are no significant differences in WTP between Rogaland and Oslo from 2019 to 2022. We are not surprised that our results are similar to Dugstad et al. (2020) due to only a three-year gap between the studies.

Despite the limitation in Chapter 7.2, the research findings help understand respondents' preferences for WPD in Norway and give an overview of people's preferences towards wind energy. Additional research in this area is required for a more reliable conclusion. Future research is encouraged to investigate "place attachment" within regions more exposed to wind power than other regions. This is to determine whether there are variations in WTP regarding the proportion of the country that is affected and exposed to wind power compared to those that are not. The sample sizes vary between the regions, which can influence our result's reliability. Considering the limitations, future research should include tests for reliability assurance and use an econometric method with a more flexible approach to capture "true" preferences. In addition, future studies may find it interesting to study historical WTP going back more than three years to detect how they vary and change over time. According to Dugstad et al. (2021), scope elasticity is a necessary validity check that has yet to be well studied in research with discrete choices. Our findings indicate that WTP shows internal scope sensitivity as attribute levels increase. This should also be incorporated into future research.

Wind power has the most cost-beneficial technology compared to other renewable energy sources. Even though there has been resistance among the Norwegian population, the government has opened license applications for WPD. Due to the commitment to meet climate goals and reduce emissions, policymakers value the positive externalities of wind power as they see its potential. In addition, Norway has a significant role in exporting energy to Europe.

Our results indicate that Norwegian households have negative preferences for increasing WPD due to its negative externalities. People are willing to pay to avoid additional WPD, especially in high-value areas. Even though people value the environment, they are favorable to an increase in renewable energy sources. Policymakers may have other interests and priorities. However, they should consider research like ours when making decisions about energy infrastructure. Policymakers could focus more on alternatives that are more accepted by the public. They should aim at finding a balance between meeting the future Norwegian energy needs and respecting the population's preferences. Conducting more research to explore the resistance could provide information for better decision-making and reduce opposition against the government. Future research will also minimize the gap between research and policymaking. In that way, policymakers could develop strategies promoting renewable energy that considers the Norwegian household's preferences.

To conclude the current study, Norwegian population on average, are still opposed to having additional onshore wind turbines. However, they are positive toward an increase in renewable energy generation and are willing to pay for it to mitigate climate change's effects.

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Appendix

Appendix 1

T – test: Education Oslo and Rogaland

```
. ttest education, by(NorDemo_fylke20) welch

Two-sample t test with unequal variances
```

Group	Obs	Mean	Std. err.	Std. dev.	[95% conf.	interval]
Oslo	508	3.433071	.041647	.9386763	3.351249	3.514893
Rogaland	279	3.111111	.056723	.9474607	2.99945	3.222772
Combined	787	3.318933	.0339968	.9537311	3.252197	3.385668
diff		.3219598	.0703703		.183743	.4601765

```
    diff = mean(Oslo) - mean(Rogaland)                        t =   4.5752
H0: diff = 0                         Welch's degrees of freedom =  569.837

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

T – test: Income Oslo and Rogaland

```
. ttest income, by(NorDemo_fylke20) welch

Two-sample t test with unequal variances
```

Group	Obs	Mean	Std. err.	Std. dev.	[95% conf.	interval]
Oslo	482	10.73237	.0461824	1.013911	10.64162	10.82311
Rogaland	268	10.72388	.0640517	1.048572	10.59777	10.84999
Combined	750	10.72933	.0374547	1.02574	10.6558	10.80286
diff		.0084845	.0789648		-.1466324	.1636015

```
    diff = mean(Oslo) - mean(Rogaland)                        t =   0.1074
H0: diff = 0                         Welch's degrees of freedom =  538.094

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.5428         Pr(|T| > |t|) = 0.9145          Pr(T > t) = 0.4572
```

T – test: Education Oslo and Rogaland

```
. ttest age, by(NorDemo_fylke20) welch

Two-sample t test with unequal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
    Oslo |     515    44.91262    .7474765    16.96294    43.44414    46.38111
Rogaland |     284    48.63732    .9681359    16.31532    46.73166    50.54299
---------+--------------------------------------------------------------------
Combined |     799    46.23655     .595057    16.82023    45.06848    47.40461
---------+--------------------------------------------------------------------
    diff |           -3.724703    1.223114               -6.126768   -1.322637
------------------------------------------------------------------------------
    diff = mean(Oslo) - mean(Rogaland)                            t =  -3.0453
H0: diff = 0                            Welch's degrees of freedom =  604.933

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0012         Pr(|T| > |t|) = 0.0024          Pr(T > t) = 0.9988
```

Appendix 2

ANOVA – age and regions

```
                        Analysis of variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      3548.05341      4   887.013351      3.24     0.0116
 Within groups      933393.879   3407   273.963569
------------------------------------------------------------------------
    Total           936941.932   3411   274.682478

Bartlett's equal-variances test: chi2(4) =   1.2493    Prob>chi2 = 0.870
```

Bartlett's equal-variances test: chi2(4) = 1.2493 Prob>chi2 = 0.870

```
         Comparison of Hva er din alder?
          by I hvilket fylke bor du? (Bonferroni)
Row Mean-|
Col Mean |    Nord-No     Midt -    Vestlan    Sørland
---------+--------------------------------------------
 Midt -  |   -2.88466
         |      0.190
         |
 Vestlan |   -1.04482    1.83984
         |      1.000      0.660
         |
 Sørland |    .925595    3.81026    1.97042
         |      1.000      0.006      0.484
         |
Østlande |   -1.13045    1.75422   -.085623   -2.05604
         |      1.000      0.505      1.000      0.215
```

ANOVA – Education and region

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	16.6267385	4	4.15668463	4.37	0.0016
Within groups	3195.36257	3361	.950717812		
Total	3211.9893	3365	.954528768		

Bartlett's equal-variances test: chi2(4) = 2.7881 Prob>chi2 = 0.594

Comparison of Hva er din høyeste fullførte utdanning?
by I hvilket fylke bor du?
(Bonferroni)

Row Mean-Col Mean	Nord-No	Midt -	Vestlan	Sørland
Midt -	.158767 0.291			
Vestlan	.171211 0.103	.012445 1.000		
Sørland	.114379 1.000	-.044387 1.000	-.056832 1.000	
Østlande	.236139 0.001	.077373 1.000	.064928 1.000	.12176 0.214

ANOVA – Income and region

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	5.86370543	4	1.46592636	1.40	0.2313
Within groups	3361.9858	3211	1.04702143		
Total	3367.8495	3215	1.04754261		

Bartlett's equal-variances test: chi2(4) = 3.5883 Prob>chi2 = 0.465

Comparison of
Omtrent hvor stor er denne husstandens samlede brutto årsinntekt (før skatt og f
by I hvilket fylke bor du?
(Bonferroni)

Row Mean-Col Mean	Nord-No	Midt -	Vestlan	Sørland
Midt -	-.055172 1.000			
Vestlan	-.082057 1.000	-.026884 1.000		
Sørland	-.109493 1.000	-.05432 1.000	-.027436 1.000	
Østlande	-.001934 1.000	.053238 1.000	.080123 0.931	.107559 0.575

Appendix 3

ANOVA – Affected and region

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	132.794202	4	33.1985504	19.43	0.0000
Within groups	5643.51142	3303	1.7086017		
Total	5776.30562	3307	1.74669054		

Bartlett's equal-variances test: chi2(4) = 373.9203 Prob>chi2 = 0.000

Comparison of VDH by I hvilket fylke bor du?
(Bonferroni)

Row Mean-Col Mean	Nord-No	Midt -	Vestlan	Sørland
Midt -	-.204974 0.386			
Vestlan	-.357225 0.001	-.152252 0.579		
Sørland	.187661 0.573	.392635 0.000	.544887 0.000	
Østlande	.09821 1.000	.303184 0.000	.455436 0.000	-.089451 1.000

.

Appendix 4
ANOVA – Distance_Turbines and region

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	.720453147	4	.180113287	1.00	0.4038
Within groups	607.914598	3390	.17932584		
Total	608.635052	3394	.179326768		

Bartlett's equal-variances test: chi2(4) = 37.2787 Prob>chi2 = 0.000

Appendix 5
ANOVA – Power_sources and regions

Analysis of variance

Source	SS	df	MS	F	Prob > F
Between groups	12.7198614	4	3.17996535	0.53	0.7107
Within groups	19224.214	3229	5.95361225		
Total	19236.9338	3233	5.95018058		

Bartlett's equal-variances test: chi2(4) = 12.7957 Prob>chi2 = 0.012

Comparison of VBD by I hvilket fylke bor du?
(Bonferroni)

Row Mean-Col Mean	Nord-No	Midt -	Vestlan	Sørland
Midt -	-.188258 1.000			
Vestlan	-.055886 1.000	.132372 1.000		
Sørland	.014088 1.000	.202346 1.000	.069974 1.000	
Østlande	-.004666 1.000	.183592 1.000	.05122 1.000	-.018754 1.000

Appendix 6

Attributes and levels	FULL Coef. (S.e.)	NORTH Coef. (S.e.)	CENTRAL Coef. (S.e.)	WEST Coef. (S.e.)	EAST Coef. (S.e.)	SOUTH Coef. (S.e.)
Fee	-0.0002*** (7.18e-06)	-0.0002*** (0.00002)	-0.0001*** (0.00001)	-0.0002*** (0.00001)	-0.0001*** (0.00001)	-0.0002*** (0.00001)
20 TWh	0.2100*** (0.0275)	0.2015** (0.0933)	0.2032** (0.0766)	0.1815** (0.0606)	0.1213 (0.0761)	0.02528*** (0.0414)
30 TWh	0.3422*** (0.3857)	0.1737 (0.1306)	0.3349** (0.1073)	0.4395*** (0.0857)	0.1201 (0.1063)	0.4000*** (0.0579)
40 TWh	0.4480*** (0.0475)	0.3796** (0.1620)	0.3276** (0.1320)	0.4795*** (0.1057)	0.2871** (0.1315)	0.5303*** (0.0712)
700 Turbines	-0.4342*** (0.0342)	-0.4739*** (0.1163)	-0.3947*** (0.0949)	-0.6033*** (0.0757)	-0.4498*** (0.0945)	-0.3548*** (0.0513)
1 400 Turbines	-0.6272*** (0.0358)	-0.5874*** (0.1209)	-0.6134*** (0.0997)	-0.9020*** (0.0811)	-0.5032*** (0.0982)	-0.5524*** (0.0535)
2 100 Turbines	-0.7740*** (0.3615)	-0.7257*** (0.1234)	-0.7022*** (0.1001)	-1.0300*** (0.0804)	-0.6822*** (0.1000)	-0.7129*** (0.0540)

Notes: ***p<0.01, **p<0.05, *p<0.1. Standard errors (s.e.) are given in brackets.

Appendix 6

Attributes and levels	FULL Coef. (S.e.)	NORTH Coef. (S.e.)	CENTRAL Coef. (S.e.)	WEST Coef. (S.e.)	EAST Coef. (S.e.)	SOUTH Coef. (S.e.)
Fee	-0.0002*** (7.18e-06)	-0.0002*** (0.00002)	-0.0001*** (0.00001)	-0.0002*** (0.00001)	-0.0001*** (0.00001)	-0.0002*** (0.00001)
20 TWh	0.2100*** (0.0275)	0.2015** (0.0933)	0.2032** (0.0766)	0.1815** (0.0606)	0.1213 (0.0761)	0.02528*** (0.0414)
30 TWh	0.3422*** (0.3857)	0.1737 (0.1306)	0.3349** (0.1073)	0.4395*** (0.0857)	0.1201 (0.1063)	0.4000*** (0.0579)
40 TWh	0.4480*** (0.0475)	0.3796** (0.1620)	0.3276** (0.1320)	0.4795*** (0.1057)	0.2871** (0.1315)	0.5303*** (0.0712)
700 Turbines	-0.4342*** (0.0342)	-0.4739*** (0.1163)	-0.3947*** (0.0949)	-0.6033*** (0.0757)	-0.4498*** (0.0945)	-0.3548*** (0.0513)
1 400 Turbines	-0.6272*** (0.0358)	-0.5874*** (0.1209)	-0.6134*** (0.0997)	-0.9020*** (0.0811)	-0.5032*** (0.0982)	-0.5524*** (0.0535)
2 100 Turbines	-0.7740*** (0.3615)	-0.7257*** (0.1234)	-0.7022*** (0.1001)	-1.0300*** (0.0804)	-0.6822*** (0.1000)	-0.7129*** (0.0540)
Pseudo R-squared	0.0328	0.0388	0.0273	0.0495	0.0315	0.0331

*Notes: ***p<0.01, **p<0.05, *p<0.1. Standard errors (s.e.) are given in brackets*

Appendix 7

Attributes and levels	ROGALAND Coef. (S.e.)	OSLO Coef. (S.e.)
Fee	-0.0002*** (0.00002)	-0.0002*** (0.00001)
20 TWh	0.2132** (0.0986)	0.2650*** (0.0703)
30 TWh	0.4632*** (0.1389)	0.3160*** (0.0976)
40 TWh	0.5659*** (0.1715)	0.4539*** (0.1199)
700 Turbines	-0.7762*** (0.1234)	-0.2583*** (0.0867)
1 400 Turbines	-1.1212*** (0.1333)	-0.4182*** (0.0894)
2 100 Turbines	-1.2048*** (0.1333)	-0.5893*** (0.0915)
Pseudo R-squared	0.0689	0.0332

*Notes: ***p<0.01, **p<0.05, *p<0.1. Standard errors (s.e.) are given in brackets*

Appendix 8

Attributes and levels	EXPOSED_ CENTRAL Coef. (S.e.)	NONEXPOSED _CENTRAL Coef. (S.e.)	EXPOSED_ WEST Coef. (S.e.)	NONEXPOSED _WEST Coef. (S.e.)
Fee	-0.0001** (0.00004)	-0.0002*** (0.00002)	-0.0001*** (0.00003)	-0.0002*** (0.00001)
700 Turbines	-0.5106** (0.2169)	-0.4030*** (0.1111)	-0.7410*** (0.1588)	-0.5368*** (0.0928)
1 400 Turbines	-0.5386** (0.2259)	-0.7085*** (0.1175)	-0.7889*** (0.1668)	-0.8922*** (0.0995)
2 100 Turbines	-0.5439** (0.2258)	-0.7962*** (0.1175)	-0.8661*** (0.1666)	-1.0482*** (0.0988)
Pseudo R-squared	0.0281	0.0346	0.0482	0.0467

*Notes: ***p<0.01, **p<0.05, *p<0.1. Standard errors (s.e.) are given in brackets.*

Appendix 9

Attributes and levels	AFFECTED Coef. (S.e.)
Fee	-0.0002*** (7.26e-06)
20 TWh	0.2239*** (0.0293)
30 TWh	0.3537*** (0.0410)
40 TWh	0.4667*** (0.0505)
700 Turbines	-0.4056*** (0.0362)
1 400 Turbines	-0.0599*** (0.0378)
2 100 Turbines	-0.7614*** (0.0381)
20 TWh x AFFECTED	-0.0666 (0.0932)
30 TWh x AFFECTED	-0.0420 (0.1300)
40 TWh x AFFECTED	-0.1291 (0.1605)
700 Turbines x AFFECTED	-0.1705 (0.1088)
1 400 Turbines x AFFECTED	-0.1478 (0.1135)
2 100 Turbines x AFFECTED	-0.0532 (0.1128)
Pseudo R-squared	0.0328

*Notes: ***p<0.01, **p<0.05, *p<0.1. Standard errors (s.e.) are given in brackets.*

Appendix 10

```
. mixlogit response_ fee, rand(twh20 twh30 twh40 turbine700 turbine1400 turbine2100) group(group_id) id(id) nre
> p(200)

Iteration 0:   log likelihood = -15181.889  (not concave)
Iteration 1:   log likelihood =     -11928
Iteration 2:   log likelihood = -11433.102
Iteration 3:   log likelihood = -11357.633
Iteration 4:   log likelihood = -11350.603
Iteration 5:   log likelihood =  -11349.85
Iteration 6:   log likelihood = -11349.848
Iteration 7:   log likelihood = -11349.848

Mixed logit model                                 Number of obs =  45,438
                                                  LR chi2(6)    = 7761.43
Log likelihood = -11349.848                       Prob > chi2   =  0.0000

------------------------------------------------------------------------------
   response_ | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
Mean         |
         fee |  -.0006603   .0000224   -29.44   0.000    -.0007042   -.0006163
       twh20 |   .7896645    .065819    12.00   0.000     .6606616    .9186674
       twh30 |    1.24208   .0969651    12.81   0.000     1.052032    1.432128
       twh40 |   1.563325    .109805    14.24   0.000     1.348112    1.778539
  turbine700 |  -1.435079   .1308757   -10.97   0.000     -1.69159   -1.178567
 turbine1400 |  -2.194584   .1386089   -15.83   0.000    -2.466252   -1.922915
 turbine2100 |   -2.61835   .1511552   -17.32   0.000    -2.914609   -2.322091
-------------+----------------------------------------------------------------
SD           |
       twh20 |   .1080643   .1283073     0.84   0.400    -.1434134    .3595419
       twh30 |   .0230959   .0963232     0.24   0.811    -.1656942    .2118859
       twh40 |  -1.179467   .1509332    -7.81   0.000     -1.47529   -.8836432
  turbine700 |   5.179375   .2039648    25.39   0.000     4.779612    5.579139
 turbine1400 |   5.254557     .24124    21.78   0.000     4.781735    5.727378
 turbine2100 |   5.700885    .247497    23.03   0.000       5.2158     6.18597
------------------------------------------------------------------------------
```

Do-file from Stata available on request.